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ANNALS

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VOLUME III.

I.—*The Patio and Cazo Process of Amalgamating Silver Ores.*

BY THOMAS EGLESTON.

Read, October 1st, 1883.

The process of amalgamation which is still used both in Mexico and Chili, is called the American method of amalgamation, in order to distinguish it from the process used so long at Freiberg, known as the Freiberg Barrel Amalgamation, and that which has now for so many years been almost exclusively used in the western part of this country, known as Pan Amalgamation. It is effected in two different ways, according to the country in which it is used. In Mexico it is called the Mexican or Patio method, and in Chili it is known as the Chilian or Cazo method. These processes do not differ essentially, except in the mechanical appliances which are used for carrying them on. The Patio method was, until questioned by Dr. Percy,* supposed to have been invented in Mexico, about 1557, for beneficiating the silver ores which occur there.

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* Percy's Silver and Gold, Part I, p. 562, London, 1880.

The Cazo method was invented in 1609, in Peru,* and has not been used much except in South America and Mexico. The Patio method is used in Mexico on ores that have a mean yield of from thirty to sixty dollars to the ton. Ores of much higher grade than this are treated, provided they are not refractory, but when they are rebellious they are generally treated by fusion. In order to do this, however, the yield must be large, for fuel is very dear on the plains of Mexico.

It is quite rare that anything is done to the ores before treatment, except hand-picking to sort out those of high grade from those of less yield, and to remove some of the sterile material. Occasionally, however, they are treated in a rude way. At Zacatecas† very impure ores are broken by hand into small pieces, made into a pile surrounded by a rude wall laid up dry, and imperfectly roasted with charcoal. In the districts of Tasco and Sultepec, where sulphurous ores are abundant, they are roasted with wood in the same furnace, *comalillos*, in which the magistral is made, but not efficiently, though the operation lasts twelve hours. The *colas*, the concentrated sulphides, are also roasted in piles. This pile-roasting is not only very insufficiently done, but is very uncertain in its results. The object is to remove the substances which attack the mercury, but owing to defects both of fuel and arrangement of the pile, but little results from it, beyond the blind following of a routine which has little other reason than that it has been practised somewhere else. There is always danger that, in roasting these ores, the heat will be raised sufficiently high to melt them. When they are rich, a fusion treatment is much more rational. It is doubtful whether, with a dear fuel, much is gained by roasting previous to the treatment on the *patio*.

It is generally the gangue which determines the name of the ore, but it is sometimes called after its size. Quartz is called *guija*, and quartzose ore *guijoso*; feldspar is called *caliche*; feldspathic ores, *calichoso*. When there is much gangue it is said to be *desploblado*. *Quemazon* is a black porous decomposed ore. Large pieces of the first and second class ores are called *gabarro*. The smalls are called *metal granza*.

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* Percy's Silver and Gold, Part I, p. 656.

† Phillips's Gold and Silver, p. 352, London, 1867.

The minerals which are usually found as ores, or associated with them, are native silver, *plata;* kerargyrite, *plata cornea blanca;* embolite, *plata cornea verde;* bromyrite, *plata verde;* iodyrite, *plata cornea amarillia;* argentite, *plata negra;* ruby silver, *rosi clara;* arsenopyrite, *ferro blanco;* galena, *plomo;* and zinc blende, *copelilla.*

The ores are generally distinguished as of two kinds, the black, *negros,* and the colored, *colorados.* The former are found in the lower part of veins, and comprise all the ores containing sulphur. The *colorados* are found in the upper parts of veins, and are composed generally of the iodides, bromides and chlorides, with some native silver mixed with them. The gangue is generally oxide of iron, carbonate of lime, or quartz; occasionally some argillaceous schists which, when they are not attacked by the reagents, can be as easily treated as the others. This method is the only one that can be used in many places in Mexico, on account of the high price of fuel.

In some places, the very rich rebellious ore is roasted and then treated, and this should always be done with all the *negros* when fuel is not so dear as to render such a treatment impossible. When the gangue is attacked to any extent this process cannot be used. The works where these operations are carried on are called *haciendas.*

The process consists of five different operations:—

1. Crushing the ore in a Chilian mill, California stamp, or a breaker.
2. Grinding and amalgamating the ore in an arrastra.
3. Treatment on the patio.
    - *a.* Making the *torta.*
    - *b.* Introducing the reagents.
    - *c.* Separating the amalgam.
4. Treatment of the amalgam.
5. Refining the silver.

The following tree, prepared by Mr. R. E. Chism,* gives a very accurate idea of all the details of the process.

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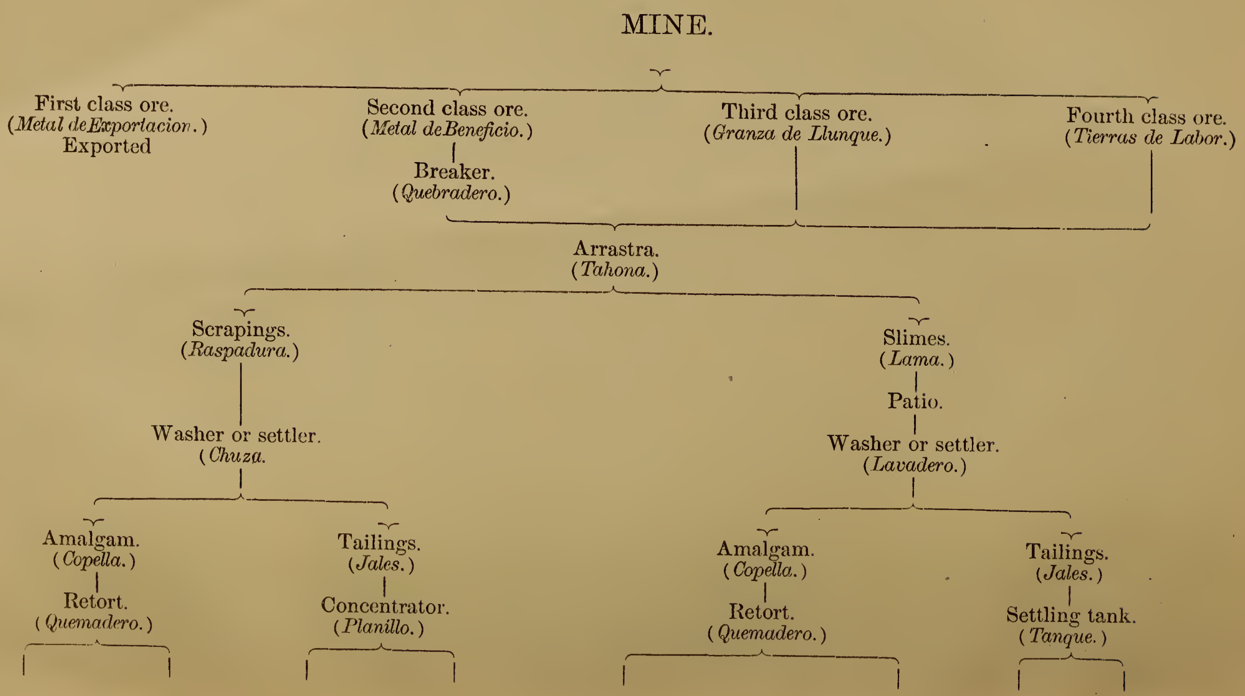
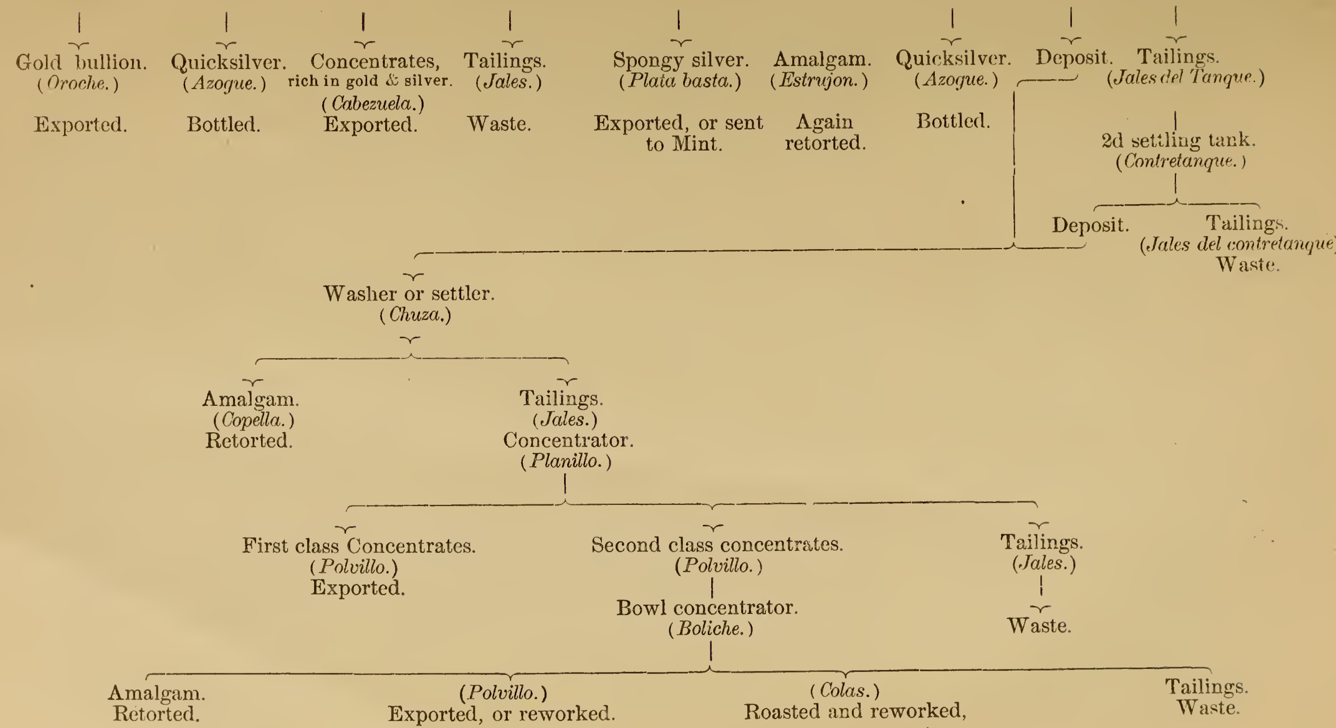
* Patio Process, San Dimas, Trans. Am. Min. Engs., Vol. XI, Pl. 1.

SCHEME OF PATIO PROCESS.




Gold bullion.
(Oroche.)
Exported.
Quicksilver.
(Azogue.)
Bottled.
Concentrates,
rich in gold & silver.
(Cabezuela.)
Exported.
Tailings.
(Jales.)
Waste.
Spongy silver.
(Plata basta.)
Exported, or sent to Mint.
Amalgam.
(Estrujon.)
Again retorted.
Quicksilver.
(Azogue.)
Bottled.
Deposit.
Tailings.
(Jales del Tanque.)
2d settling tank.
(Contretanque.)
Deposit.
Tailings.
(Jales del contretanque)
Waste.
Washer or settler.
(Chuza.)
Amalgam.
(Copella.)
Retorted.
Tailings.
(Jales.)
Concentrator.
(Planillo.)
First class Concentrates.
(Polvillo.)
Exported.
Second class concentrates.
(Polvillo.)
Bowl concentrator.
(Boliche.)
Tailings.
(Jales.)
Waste.
Amalgam.
Retorted.
(Polvillo.)
Exported, or reworked.
(Colas.)
Roasted and reworked,
Tailings.
Waste.

1. Crushing the Ore.

The amalgamating works consist of a large court, *patio*, surrounded by sheds, *galera*, in which the apparatus for comminuting the ores is placed. All of the ore to be treated must be reduced to an impalpable powder. The court is always paved in some way, generally with stones; and if it is desirable that it should contain only a single pile, is only 10 or 15 meters square. When a number of piles are made in the same enclosure, it must be very large, as the piles are often 7 or 8 meters in diameter. The court then would be 50 or 60 meters square, or even larger.

The ores are generally sorted according to their silver contents and gangue, into three or four classes. At San Dimas* there are four grades. The first is the lumps of pure ore picked out by hand, *metal hecho*, or made ore, free from gangue, worth $400 or more to the ton. This is called *metal de primera classe* or *metal de exportacion.* The second is ore for the patio, called *metal de beneficio.* It differs from the first only in being of less value and by having gangue mixed with it. The third class embraces the smalls from the hand-picking, and varies in value according to the value of the ores from which it is selected. It is called *granza de llunque* or *tierras de llunque.* The fourth class comprises the smalls from the mine. It is mixed with much gangue and dirt. It is called *granza de labores* or *tierras de labores.* At Chihuahua,† where the ores are almost entirely composed of native silver in a calcite gangue, they are separated into three classes; the first containing more than $2,500 to the ton; the second, more than $1,000 and less than $2,500; the third class, under $1,000 and averaging about $250.

This classification, however, differs at every works; the first consideration being always the value of the ore; the second, the kind and quantity of gangue, according as it may or may not be attacked by the reagents; and lastly, the size of the pieces.

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* Patio Process at San Dimas. Trans. Am. Min. Eng., Vol. XI.

† Rept. United States Mining Commissioner, 1874, p. 435.

At Chihuahua the third class ore is carried to the stamps; *morteros*, the best ore, is carried to the store-house, from which it is weighed out. The ore is crushed with small stamps, weighing about 150 kilos each, with a fall of 0.20 m. to 0.25 m. The slots of the screens are 0.15 m. wide. The coarse sand which passes the screens is called *granza*. The lumps of native silver which do not pass through the screens are cleaned by hand. The stamps are run by a horizontal water-wheel. From the stamps the ore is taken to the arrastra. At San Dimas, and generally in the whole country, the ore which is not small enough is broken by hand, until it is small enough to be stamped in old-fashioned German stamps, with wooden stems and iron shoes. Three stamps, weighing 0.50 kil. each, with a drop of 0.22 m., are capable of crushing and forcing out of a screen with 0.15 slots, about 8 tons in 24 hours. These stamp mills, *molinos*, are sometimes run by mule power. In some works rolls are used.

The Chilian mill, *trapiche*, is also still in use. This was formerly a large stone, generally granite, about two meters in diameter, with an edge of 0.40 m. wide, weighing between three and four tons. It was made to revolve on the circumference of an enclosure formerly built up of stones, on a long horizontal arm, which pivoted on a heavy piece of metal driven into a post placed in the centre of the grinding space. When metal was not easily procured, the beam was made to turn on a piece of tough wood. The stone revolved on one end of this beam. The other end projected beyond the outer edge, and to it a horse or mule was attached. The inside diameter of the stone is slightly smaller than the outside, so that it inclines somewhat toward the centre. Sometimes, instead of having one stone only, two stones are placed on the same arm, on opposite sides of the circle, and at different distances from its centre. These wheels run on a bed of hard stone. Sometimes the crushing is done dry; but it is generally done wet—the ground ore being washed out and allowed to settle. The more modern mill* consists of a large wheel, of iron or

* Eng. and Min. Jour., Vol. XXXIII, p. 104.

stone, 1.65 m. in diameter and 0.38 m. wide. It is bound together with an iron tire 0.10 m. thick. It rotates on a horizontal shaft attached to a vertical one. The other end of the shaft projects so that a mule can be harnessed to it. The wheel runs in a circular space made of iron, which is 0.50 m. wide, on the inside of which there is a screen of five or six meshes to the inch. When there are two wheels, the axis is generally about three meters high, and turns on pivots—one fixed in a step raised above the bottom of the grinding-space, and the other held by a frame above. The arm on which the wheels revolve is fixed to this axis, and the power is communicated by an arm fixed above on the axis. This arm may be single for one mule, or may project on both sides; in which case yokes are attached so that a mule can be harnessed at each end. The number of these mills depends on the amount of work to be done. When the amount is small, mules are always used; but when it is large, water power or steam is the motor.

In some of the works both the Chilian mill and the stamps have been abandoned for a series of crushers, *Quebraderos*, or for [illegible] a single one. In this way, by a machine readily managed and repaired, a much larger amount of material can be prepared for the arrastra than by either of the other machines.

2. Grinding and Amalgamating the Ore in the Arrastra.

The crushed ore goes from the stamps or Chilian mill to the arrastra, which is a very important part of the process, as the yield of the ore depends very largely on the work which is done in it. Its action is very slow, but no machine yet invented can compete with it in the efficiency of its work. The arrastra is generally circular and somewhat below the level of the ground. It is from 3 to 4 meters in diameter. The bottom is sometimes made of the hardest boulders that can be found in the country, bedded in clay with their smooth sides turned up and ground to something like even surfaces before the operation begins. This is a bad construction, as the open places between the stones would seem likely to produce a large loss of both mercury and amalgam. It is surprising, however, that with such a rude construction the loss of mercury is not very much larger than in the better-constructed ones. This is owing to the great skill which the men have acquired, not only in working, but in picking out the mercury and amalgam from the cracks, and refilling with slimes. Such an arrastra will have to be run the longest time possible, fifteen or twenty days, before a clean-up is made. It will then generally be found expedient to remove the tailings and work up all the material in the interstices. A properly constructed arrastra can, however, be cleaned up every few days without disturbing the pavement. It is generally built of paving stones or slabs of quartzose porphyry. In the best works, the edges of these stones are carefully dressed and they are put together with cement, or when that cannot be had, with the very fine tails which result from washing up the *torta*. These stones are 0.75 m. in length. They are placed vertically. When put in with care, the bottom will last for twelve months. It will then be necessary to clean out all the cracks and repair it, taking up the stones, carefully scraping them, and washing the dirt upon them and that beneath them, to recover any mercury or amalgam that may have penetrated into the ground. The sides are made generally of flat stones forming a rough curbing 0.60 m. high, which projects enough to make the interior about 0.60 m. deep. In the centre of the arrastra, raised above the bottom, is a pivot hole for the central shaft, which carries four arms, and is supported above and below. To each of these arms one and sometimes two stones are attached, which act as mullers, *voladoras*, to grind the ore. They are made of quartzose porphyry, which must have an open grain so as to present a good grinding surface until it is entirely worn out. A close-grained stone would become smooth after a little wear, and would then be no longer serviceable. They are usually, when there is only one to each arm, a little smaller than the half diameter of the arrastra and about 0.40 m. thick. Two holes are drilled in each one; into these, wooden plugs are driven to receive staples, by which they are fastened to the arms by means of thongs, leather, or chains, in such a way that their front edges will be about 0.05 m. above the bottom, while the rear drags. When new, all the stones together weigh from 300 to 800 kilos. The arms are sometimes niched so as to allow of changing the position of the stones at will. There are usually four of these mullers, but sometimes only two, and in very rude arrastras only one is used. They do not last much over a month, and are sometimes worn out before that time. When they are worn down to about 200 kilos they are replaced one at a time, so that there are always old and new stones in the mill at the same time.

The arrangement of the arms differs according as animal or water-power is to be used. When mules are used, one of the arms is made to project over the side of the arrastra, and to it one and sometimes two mules are hitched. Such arrastras are called *arrastra de mula,* or when they are of large size, *arrastra de marca.* When water power is to be used, all the horizontal arms project beyond the rim. From these arms rods descend, which support a horizontal wheel, which revolves around outside of the arrastra a few centimeters above the pit. In the circumference of this wheel, at intervals of 0.15 m., rectangular floats, slightly concave, and set edgewise, are placed. These are called spoons, *cucharas,* and these arrastras are distinguished as spoon arrastras, *tahona* or *arrastra de cuchara,* in distinction from the *arrastra de mula.* The men in charge of the grinding are called *tahoneros.* The water strikes these paddles, the power being acquired while descending through a tapering shoot which has a fall of 0.20 m. in every 3.5 m. to 4.5m. This horizontal water-wheel runs in a channel a few centimeters deep on the outside of the arrastra, as shown in the plate.* If the central space, called *tosa,* which is the arrastra proper, is three meters in diameter, it is usually not more, and about 0.50 m. deep, the wheel six meters in diameter with a width of from 0.60 m. to 0.70 m., the outside diameter of the ditch would be about 7 m. Such an arrastra would treat between 400 to 600 kilos of soft ore in twenty-four hours, or if it is hard, 700 and 800 kilos in about three days. This is a wasteful appliance, but there is a superabundance of water, so that it makes little difference. These arrastras are constantly employed when water-power can be

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* I am indebted to Dr. Drown, the obliging Secretary of the Am. Inst. of Min. Eng., for the cliches taken from Mr. E. Chism's paper.

had. A wheel of this kind with a diameter of six meters will carry two mullers for 24 hours without stopping, as fast as four mules will, that cannot work for more than eight hours a day.* At Chihuahua such a wheel runs both the arrastra and the stamps. When overshot water-wheels are used, the power is transmitted by spur gearing on the upper part of the central shaft.

In some few cases an overshot water-wheel is used to run a number of arrastras. The power is transmitted by wooden gearings. When the arrastra is new, or when a new bottom has been put in, *rebajado,* it is turned either empty or with a few *cargas* of tailings, *jales,* or low grade ores, *tierras de labor,* so as to make the stones even and fill up the cracks—if the stones have been simply laid together—with material of but little value.

A good deal of importance is attached to the use of the proper quantity of water, and to the times as well as the way in which it is added. When a new bottom has been put in, one muller is attached to the arm, and it is set to work grinding up with water the residues of the washing of a *torta,* to smooth down the pavement and to fill up any cracks. This is continued for one day. The next day another muller is attached; the third day another. On the fourth day poor ores are charged; at the end of four or five days, the fourth muller is attached, and the usual work is then commenced. From one-half to two-thirds of the total quantity of ore to be treated is added at first. If there is any free gold or silver in the ore, a little mercury is added at the start in order to catch it. The quantity of gold contained in most Mexican ores is so small, that if it was not separated in some way in the treatment, it would be absorbed in the silver, and its separation by a parting process would hardly pay, so that it would be lost; but by adding mercury, especially that which has already been through the arrastra, much of it is collected. When the ores contain a very considerable quantity of native gold or silver, it is desirable to collect as much as possible with mercury in the arrastra; and if no other minerals are associated with it, the whole or the greater part of the treatment, as at Chihuahua, is comprised in its treatment here.

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*Report of the U. S. Mining Commission, 1872, p. 436.

The usual charge is one ton; it is often greater in large and less in small arrastras. When the charge has been introduced, a few buckets of water are thrown in to make a sufficiently consistent mud, about half the total quantity used being added at first. If there is too little water, the ore is raised and pushed forward by the mullers without being ground. If there is too much, it packs underneath the mullers. Care is taken to add the water as required, to keep the proper consistence. To do the work most efficiently, the mullers should be made to revolve slowly at first, but when the larger pieces have become reduced, the motion is increased to from six to ten turns a minute. This is sufficiently rapid to prevent the larger and heavier pieces from settling and thus clogging the *voladoras*, and does not make the charge rise over the sides. When the ore has been ground about eight hours, quicksilver is added in sufficient quantities to amalgamate the free gold and silver. The quicksilver is usually amalgamated with either silver, copper or zinc. The quantity added depends on the quantity of gold and silver in the ore, and on the quantity to be worked before a clean-up is made.

When the arrastra is new, or immediately after a clean-up, from two to five kilograms of mercury are added at once. When the work is going on regularly, it is 0.25 kilog. every second day. If there is no free gold or silver, no mercury is added in the arrastra. When 400 kilograms are treated per day, which makes about 12 tons a month, six kilograms of amalgam, containing about 4.5 kilos. of quicksilver, are used. This acts readily as long as there is plenty of free mercury present; but as this becomes saturated with the precious metals, fresh quantities must be added; and to determine what this quantity should be, assays, *tentadura*, of the amalgam taken from the bottom, made by washing in a horn spoon, must be made every day or two. Sometimes the assay is made on a red earthen plate, *platillo*, which is used as a pan.

It is desirable that the amalgam should not be too liquid, for it is then liable to roll into the crevices and be caught there. If, however, it is too dry, the mercury, being already nearly saturated, will not attack the precious metal. A properly constituted amalgam flattens and spreads itself out, and presents large surfaces for contact; a liquid one rolls around in globules and may sink into the interstices; and even if it does not, is not so likely to catch the precious metal.

In some places, a quarter of the arrastra* is cleaned to the bottom, and the mixture of ore and amalgam taken out and washed. This, however, is not usually done, except in very small tortas, when the ores being treated are new, or, for some reason, do not work well. Usually the assay is taken by probing in different parts; the different probings being put together and then tested in a small vessel called a *jicara,* by pressing the thumb or finger against the side. With a very little experience the quantity of mercury is quickly arrived at without so large an assay, and the horn-spoon assay is sufficiently exact. When the amalgam is too dry, more mercury must be added. Generally, it is not desirable that the amalgam collected should contain more than 20 per cent. of gold and silver.

The quantity that a single arrastra can grind in 24 hours varies with the hardness and the richness of the ore. It will generally be from 400 to 600 kilos., and will require the use of from 900 to 1200 liters of water. When no grit can be felt between the thumb and forefinger, the work of the arrastra is regarded as complete. When the hands of the men who do the work are not very sensitive, they sometimes make the test by rubbing some of the pulp on the lobe of the ear. There is considerable difference in the fineness of the pulp in different sections. With coarse ore, the amalgamation will not be so perfect; but those who use this practice, claim that the greater yield of fine pulp does not pay the extra expense, and that the economy in production and quicker returns more than pays for the loss in yield. Those who grind fine, maintain the contrary, and claim that their results are satisfactory, in yield, expense and time. Probably the differences in the qualities of the ore have led to the differences in practice in the various districts. When the assay shows that the work is properly done, water is introduced to thin down the mixture and allow the heavier particles to settle. The thin slimes, *lama,* are either dipped out into barrels and carried to the slime-pits, *lameros,* or into launders, from

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* Engineering and Mining Journal. Vol. 83. p. 104.

which they run into the settling-vats. Sometimes a spout or plug is put into the sides of the arrastra for the purpose of allowing the pulp to flow into the *launders.* These troughs are removed as soon as they have been used. When the pulp is dipped out, a cover is put on the floor of the arrastra to protect the amalgam. When no protection is used, care is taken not to go near the bottom. The whole of the slimes are not removed at any one time, except to make a clean-up. In the pits, the slimes are allowed to settle until they are ready to be carried to the *patio.* It takes about three days to grind a charge.

At Chihuahua, on native silver ores, the arrastra is generally charged with a ton per day of third-class ore, yielding from $250 to $1,000 per ton, requiring about 25 lbs. of mercury. After three days' run, ore as rich as $2,500 is added, which requires more quicksilver. As much of this ore is added as is necessary for the purpose of getting a suitable amount of amalgam collected in the arrastra, preparatory to the clean-up. Some hours after adding quicksilver, the amalgamator, *azugero,* takes an assay with the horn spoon, washes it, and judges whether the proper amount of quicksilver is present. These assays are regularly made, and by means of them great skill is rapidly acquired in learning how to add the mercury. Every morning, after the silver seems to be amalgamated, a large quantity of water is added to the material in the arrastra, and kept in motion from four to six hours. This separates the amalgam from the fine ore, and allows the heavier particles to settle to the bottom. The fine material which has not been amalgamated runs off, carrying with it all the finely ground ore. The coarse grains, not yet sufficiently reduced, remain and are ground in the next charge. The tails which are thus obtained at Chihuahua are poor, so poor that they are not worth more than $3 a ton for the patio process. They contain all the ores other than silver, except a small part of the ruby and sulphide of silver, which have been reduced at the expense of the mercury. The sulphide of silver, being ductile, is not reduced to powder, but settles to the bottom of the arrastra, and is taken out with the amalgam. Any rich tailings which come from the treatment of rich silver ore which has been added just before the clean-up, are saved for concentration or treatment.

After a number of charges have been ground, the process of grinding is stopped to allow of collecting the amalgam, which is done by scraping the inside of the arrastra with great care. This operation is called *raspando.* In the most primitive arrastras it is performed as often as twice a month, or perhaps not oftener than twice in three months. In those of the best construction it is done from two to four times a year. As a properly made pavement lasts about a year there is no necessity for doing it oftener. It is done by carefully scraping the stones and the intervals between them with a curved tool, in order to be certain to remove every particle of ore and amalgam; the amalgam so collected is called *raspa* or *raspadura.* In case the pavement is worn out, each stone is carefully scraped and washed, and the earth for a slight depth as well. In some places the *raspa* is simply washed with the addition of fresh mercury in a wooden bowl, *boliche, Fig.* 4, where most of the amalgam is collected. This operation is called *bolichar.* The tails are then washed on the *planillo, Fig.*3, a masonry platform erected for the purpose of concentrating them. The operator here is called the *planillero.* When the ore contains gold, or in the more modern works as at San Dimas, it is washed in a pit called a *chuza, Fig.* 1, which is also used for the treatment of concentrated tails from the *patio.*

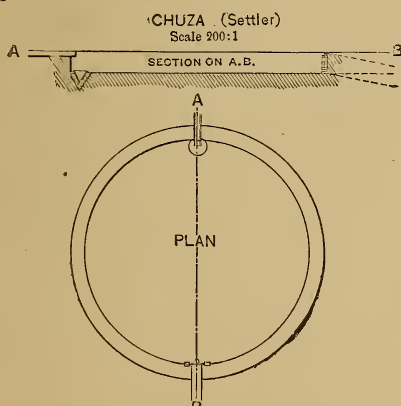

Fig. 1.

The *chuza** is an excavation 3 m. diameter and 0.5 m. deep, lined with cement, with a conical wooden bowl 0.35 m. in diameter. and 0.30 m. deep, whose sides rise 0.05 m. above the cemented bottom on one side. Directly above it at *A, Fig.* 1

* Patio Process at San Dimas.

there is a wooden trough through which water flows freely. At the opposite end there is a trough, *B*, with a gate having three plugged holes through which to let off the slimes. The scrapings are thrown into this trough and are carried by the water into the *boliche;* a boy sitting on the edge of the *chuza* keeps the material in this bowl in constant agitation with his feet. This disintegrates the material. The mercury and amalgam fall into and sink to the bottom of the bowl; the heavy particles other than these are carried into the *chuza,* and the slimes run off by the trough *B,* from which, if of value, they are collected in settling tanks, and if not, run to waste. The tails in the *chuza* are concentrated by drawing out the plugs and letting the lighter material flow away, but the work is done by hand, and yields a very rich material called *cabezuela,* which is sold. When the rich tailings have been separated, the top layer of a coarsely ground ore is removed with iron scrapers and set on one side for the next charge. The amalgam is scraped up and carried in wooden bowls, *bateas,* to the washing-tanks. The gold amalgam collected in the bowl is strained and retorted as the silver is, but not with it. The surplus mercury is not mixed with that from the straining of the amalgam from the patio. It contains considerable gold and silver, and is always used over again to catch the free gold in the arrastra, as amalgamated is always much more lively in catching free gold than pure mercury. The amount of gold separated in this way varies from 30 to 50 per cent. of the total contents of the ore. This gives a bullion that will pay to part. The rest of the gold is recovered in the *patio,* either in the direct washing of the pulp, or in that of the *polvillos,* or is lost in the float during the various processes of washing. When the ore does not contain native silver, 10 to 12 per cent. of precious metals contained are taken from the arrastra. The amalgam taken at the clean-up usually contains from 18 to 22 per cent. of silver.* The coarser the silver is, the less mercury is required.

The loss of mercury in the arrastra is owing to the formation of salts of mercury by the impurities contained in the ores, and

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* Engineering and Mining Journal, Vol. 33 p. 104 to 114.

also to the flour formed, but more especially to the latter. Phillips gives the following statement of the losses at Guanaxuato,* where the ores contain gold but very little native silver, it being in the form of sulphide:

Composition of amalgam, - - -	Silver,	14 lbs.	
	Mercury,	56 "	
Weight of amalgam used, - - - -		70 "	
Mercury added independently of amalgam, - - -			330 lbs.
Mercury in amalgam, - - - - - -			56 "
Gold and silver, *Plata Mixta*, obtained, including that used in amalgam,	Gold,	18 lbs.	84 lbs.
	Silver,	66 "	
			470 lbs.
Amalgam produced, - -	Gold and silver,	84 lbs.	400 lbs.
	Mercury,	316 "	
Loss, - - - - -			70 lbs.

As the gold was metallic it probably caused no loss. This loss of mercury is only a little more in weight than the silver contained in the bullion. It is a received opinion among the amalgamators, *azogueros*, that the loss in mercury will always be equal to the weight of silver contained in the ore.

The increase in the non-productive portion of the ore, owing to the constant wearing of the stones of the pavement and the mullers, may be as high as 8 to 10 per cent. It is a great objection to the arrastra, which has therefore been abandoned in all the other processes; but the principle of the machine is a good one, and to this principle we shall undoubtedly have to return. The constant rubbing of the surfaces of the ore by the mullers, and the grinding and constant rubbing in the presence of water, make the metal bright, and the mixing brings it in contact with the mercury. It is a notable fact that in some cases in the early days of California mining, when Mexicans with their rude appliances easily made $50 to $60 a day, the most efficient mod-

* Phillips's Gold and Silver, p. 333. London, 1867.

ern machinery did not extract more than $15 to $20. In some instances, with the best modern appliances, an ore yielding by assay $700 to $800 did not yield more than $20 to $30 when treated in pans, while fully 75 per cent. of its value was recovered by the use of the arrastra. In ores of lower grade, the rapidity of the returns compensated for the loss, but in higher grade ores it did not. It is a matter of great surprise that a machine has not yet been invented to work rapidly on the principle of the arrastra.

3. Treatment on the Patio.

a. Making the Torta.—The process of amalgamating in the arrastra is used when the ore contains considerable quantities of iodides, bromides, chlorides or native silver or gold. When there are none of these minerals present, it is only ground to be subsequently treated on the *patio,* as are also the tails from the treatment of the arrastra. The material from the arrastra is carried to the amalgamation court called the *patio.* This is an enclosure, more or less large, carefully paved and made as impervious to mercury as possible. It is inclined so that water will easily flow from it. Little by little, after several years' use, as the *tortas* are made over the whole surface of the court, the ground will become saturated with mercury. Every two or three years, and oftener if the pavement has to be replaced, and more especially when the *hacienda* has to be abandoned, it will be worth while to clean up and work the dirt beneath the floor. Very many methods have been tried to make and keep this flooring tight. It has been made of artificial stone, of cement, and of asphalt, and, in some places, of cut stone, faced on the edges and made tight with cement. In some places, as in Nevada and also in Mexico, timbers tongued and grooved like mill floors, and covered with water when not in use, have been laid down over an area of an acre and a half. Such a floor as this will last several years. All of these devices are excellent and work well; but as the expense is large, the old method continues in use, and probably will do so till the whole process is abandoned, as it doubtless will be in the course of a few years, when the railroads now being built are completed, and transportation becomes easy and cheap.

The slimes are called *lama ;* they are brought to the *patio* as a liquid mud. In order to keep it in the place assigned for the *torta,* in small works a dam of sand or old boards is made to confine it, and it is left for some time exposed to the sun and wind, to hasten the separation of the water by evaporation as well as by drainage. In larger works, the pulp flows from the arrastra into circular walled spaces called *cajetes* or *lameros,* which are used for the same purpose. After sufficient material has been collected to treat it, and when it has acquired the consistence of thick mud, the piles, called *tortas,* or *trillas,* are made. The number and size of these depend on the size of the works. For ore, they vary from 30 to 130 tons each ;* for tails, they are usually smaller, or from 16 to 20 tons. They occasionally contain from half a ton to two tons; but such *tortas* indicate working on a very small scale, and the pile is trodden by men. As the material is still too liquid to support itself, a support is made around the outside with beams or stones, the joints between them being made tight with clay. Within this enclosure the pulp is placed. It will usually be about 0.30 m. in thickness. An assay is always taken both to check the work already done by the arrastra and to know what is being done. After several days exposure, the pile will be sufficiently thick to be worked. It is spaded over and made into a regular shape of 7 to 15 meters in diameter.

b. Introducing the Reagents.—In about twenty-four hours after the shaping, from two to five per cent. of salt is scattered over the pile, as evenly as possible. With ores containing from 30 to 35 ounces of silver, four per cent. of salt, with those containing 45 to 75 ounces, about four and a half per cent. is added. The greater the amount of salt, the easier the amalgamation will be, and the more rapidly it will be effected ; but notwithstanding the gain in time, it is generally found that the cost of the salt compensates for it, so that the amount is usually restricted to between three and four per cent. The operation of putting in the salt is called *insalmoro.* The salt which is used in the process formerly came

* Phillips, p. 343, says that they vary at Guanaxuato from 30 to 80 montones, a montone there being 1.62 tons.

from the evaporation of sea-water; but this was found too expensive, on account of the long transportation. There are in Mexico a large number of salt lakes, called *lagunes,* which dry up every year. The residue contains about 20 per cent. of salt,* and fully 50 per cent. of sand. They also contain both sulphate and carbonate of soda. These impure residues, *saltierra,* are purified to be sent to the works. When purified, they contain from 70 to 90 per cent. of salt—the latter figure being seldom reached—and from 10 to 15 per cent. of carbonate of soda. The impurities make no difference in the reactions, except from there being so much less salt.

The bed of ore which is prepared with salt should be at least from 25 to 30 centimetres in thickness, depending somewhat on the consistence of the pulp. The thinner the pulp, the thicker the bed may be. In order to make the pile as homogeneous as possible, it is trodden by mules or horses—8 to 25 being required for treading a pile—the latter number being necessary for a 100 ton *torta;* 16 mules and 8 men are required for a 60 ton *torta.*† The thickness and consistence of the ore should be such that they can tread it without too much difficulty, as the work is extremely laborious. In order to have a perfectly uniform action, the slimes should not be too thick—the thickness being settled by the hoof of a mule being able to penetrate to the bottom, and to be withdrawn without difficulty—leaving a hole which does not close up for several seconds.‡ Whenever the mules stop for rest, the spading is continued. In this way the salt is thoroughly incorporated through the whole mass. This operation of treading is called *repaso.* During this time no chemical action takes place, but only a mixture of the ore and salt has been accomplished. Every possible effort has been made to do away with this treading, as it is so fatiguing to the animals, and if not well done does not allow of a full treatment of the ore. Mechanical devices of many kinds have been invented with more or less success. Weighted wheels,§ moved in various ways by mechanical devices, more or less complicated, have been

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* Laur, Metallurgie de l'Argent au Mexique; Annales des Mines, Series 6, Vol. 20, p. 65. † *Ibid.* p. 144. ‡ *Ibid.* p. 141.

§ Percy's Silver and Gold. Part I, pp. 611 and 613, tried with what seemed to be, in many cases, great success for a time; but the cost of repairs has eventually caused the return to the old way of treading with mules, which will probably be used until the process disappears. The pile is trodden and spaded during the day. The next morning it is again trodden by the mules for an hour or two, and spaded again; after which, the "*magistral*" is added. This substance was formerly a mixture of the sulphates of copper and iron, obtained exclusively by roasting iron pyrites in double-hearthed furnaces called *comalillos*. It contains some gangue, but this does not affect the treatment. The substance, however, is not of equal composition, as it is obtained by roasting copper pyrites of very variable yield. The following analyses of this *magistral* show how it may vary.

Soluble in Water.	Poor.*	Best.†	*Insoluble in Water.*	Poor.	Best.
Water,	7.60	14.84	Oxide of copper,	5.70	0.62
Oxide of copper,	2.50	6.44	Oxide of iron,	20.50	23.20
Oxide of iron,	0.57	0.20	Oxide of lead,	0.00	7.35
Lime,	3.17	0.00	Lime,	7.84	0.00
Soda,	1.47	4.19	Silica,	38.00	28.82
Sulphuric acid,	9.15	9.61	Sulphur,	2.22	2.80
Chlorine,	0.12	2.47	Insoluble,	74.26	62.79
			Soluble,	24.58	37.75
	24.58	37.75		98.84	100.54

	Poor.	Best.
Sulphate of Copper,	9.03	19.00
Oxide of Copper,	5.00	5.50
Sulphate of Iron,	6.75	14.80
Sesquioxide of Iron,	18.75	25.80
Insoluble,	60.47	34.90
	100.00	100.00

In Peru,‡ an ore of copper which contains as high as 13.62 per cent. of sulphate of copper, already an excellent magistral, is used for making it. This is roasted with salt, and when finished and ready to be used, contains about half the soluble

* Annales des Mines, 6th Series, Vol. 20, pp. 75, 76.

† Berg und Hüttenmännische Zeitung, 1881, p. 302.

‡ *Ibid.*

sulphate that it did before. This is owing to the fact that the tradition has indicated that the ore must be roasted with salt, which in this case, at least, is not only useless, but is a harmful condition. When copper ores containing sulphur are not found, but other copper ores are, these are roasted with the addition of iron pyrites for the purpose of making the sulphate of copper. When there are no ores of copper, roasted iron pyrites alone is sometimes used.* Laur cites the following experiments :—

Two *tortas* of ores easily amalgamated were made and treated in exactly the same way, and at the same time. The piles were composed as given below :—

	Sulphate of Copper. Torta.	Sulphate of Iron. Torta.
Dry Ore, - - -	2,000 kilos.	2,000 kilos.
Salt, - - -	105	105
Sulphate of Copper, - -	6	0
" of Iron, - -		6
Mercury, - - -	12	12
Water, - - -	700	700

Each *torta* contained 2,240 grams of silver. After 18 days, during which time it was necessary to add 16 grams of mercury to each of the piles, each *torta* was washed separately, and the amalgam collected and distilled, with the following result:—

Silver collected in the sulphate of copper torta, - -	1,890 grams.
" " " iron torta - -	780 "
Loss in silver in the sulphate of copper torta, - -	15.6 per cent.
" " " iron torta - - -	65 "

This explains sufficiently well why sulphate of copper is preferred, although the losses in such experiments, made in a very small way, are much more than they would be in a large *torta*. But even supposing that the loss is reduced to ten per cent., with sulphate of copper used in a large way, the loss by the use of sulphate of iron would still be 41.6 per cent.

In Chili and Peru,† considerable quantities of sulphate of

* Annales des Mines, 6th Series, Vol. 20, p. 262.

† Berg und Hüttenmännische Zeitung, 1881, p. 302.

iron are found. It is mixed with insoluble copper ores in order to produce the necessary soluble copper salts.

$$Fe_2\ 3\ SO_4 + 3\ Cu\ O = 3\ Cu\ SO_4, + Fe_2\ O_3.$$

The iron is precipitated and the sulphate of copper crystalized. The same result is obtained with malachite. Chloride of iron may also be used to produce chloride of copper.

$$Fe_2\ Cl_6 + 3\ Cu\ O = 3\ Cu\ Cl_2 + Fe_2\ O_3.$$

With atacamite, a mineral frequently found in these countries, a mixture of chloride and sulphate of copper is formed.

$$Cu\ Cl_2,\ 3\ Cu\ O + Fe_2\ 3\ SO_4 = Cu\ Cl_2 + 3\ Cu\ SO_4, + Fe_2\ O_3.$$

With chloride of iron—

$$Cu\ Cl_2,\ 3\ Cu\ O + Fe_2\ Cl_6 = 4\ Cu\ Cl_2 + Fe_2\ O_3.$$

Decomposing iron pyrites can also be used—

$$2\ Fe\ SO_4 + 2\ Cu\ O + O = 2\ Cu\ SO_4 + Fe_2\ O_3.$$

This last reaction is a little slow; but if roasted pyrites is used, it takes place very quickly. If a little excess of the oxide of copper is added, no iron is left in solution. The mixture should be roasted in such a way as not to decompose any of the sulphate of copper, but all the sulphate of iron should yield its sulphuric acid to the oxide of copper; this it is almost impossible to do. But the heat makes rapid action possible.

When no sulphate of iron can be had, as in some parts of Peru, sulphate of alumina can be used:

$$Al_2\ 3\ SO_4 + 3\ Cu\ O = 3\ Cu\ SO_4 + Al_2\ O_3.$$

The decomposition does not take place so rapidly or so completely as with the sulphate of iron, owing to the pasty condition of the alumina produced.

On account of the difficulty of obtaining the magistral, whose only efficiency is the amount of sulphate of copper that it contains, of the same strength at different times, sulphate of copper has been entirely substituted as magistral in many places for the roasted copper pyrites magistral, with great success and greater certainty and celerity of working; but, in many places, the old magistral is still used, and even when copper pyrites cannot be had, roasted iron pyrites is used.

The magistral is the most important reagent employed, and at the same time the cheapest. A little salt, more or less, makes no special difference; but an excess of magistral is always disastrous, and its effects must be attended to at once, or they will cause a serious loss of both mercury and silver. The operation of adding the magistral is called *incorporo.* Whatever magistral is used, it is scattered evenly over the surface with wooden shovels, and then thoroughly incorporated through the pile by digging it in—the operation being called *voltear la torta,* or turning the pile. When this has been done, another *repaso* is made. which is repeated every second or third day for about eight hours. The quantity of magistral added varies from one half to two per cent., according to the nature of the ore and the quantity of sulphate of copper contained in it; more being required as there are more sulphides. On the supposition that the sulphate of copper alone is of use, about five pounds to the ton of a 35 to 60 ounce ore is required. Generally from six to eight kilos of mercury, *azogue,* is added for every kilo. of silver contained in the ore in the *torta,* as determined by the fire assay. The amount of mercury put in at this time varies with the theory of the amalgamator. Some add two-thirds; others three-fourths of the lowest quantity at once; others add it in very small quantity at first, and the rest gradually. In any case, the effort is made to add it in the smallest globules possible, by walking over the pile and squeezing the mercury through a canvas bag containing not more than five or six kilograms of it, or through strainers, so as to distribute it as evenly as possible over the pile.

Immediately after the addition of the quicksilver, the animals are set to treading, the spading being done when they rest. This is continued for two hours. A solution of hot sulphate of copper is then added to the pile; the quantity being larger as the ore contains sulphur, arsenic, antimony or zinc. For ordinary pure sulphurets, about four kilograms to the ton are used. Precipitated copper, *precipitado,* in the proportion of one part of copper to five of sulphate, is also used. This cools the pile. After the sulphate is added, the *torta* is trodden again until 3 P. M. The mules employed for this purpose do no other work. They are generally blindfolded, and are driven in teams of not more than eight or nine. They are usually tied together four abreast, and are driven by a man who stands in the centre of the *torta* holding the halter, and who, by the aid of a long whip, makes them walk in such a way, commencing at the outer edge, as to cover every part of the *torta*. Sometimes two teams are at work on the same *torta* when it is very large. A day's work is from 6 A. M. to 3 P. M. It is very fatigueing. When the work of treading stops, the feet of the mules are carefully washed in a tank provided especially for that purpose, not only to recover the rich material, but also to keep the mules healthy: otherwise, being in constant contact with so much mercury, they would soon become diseased. They cannot be prevented from licking themselves, however, to get the salt the mud contains. Balls of amalgam, which often weigh* from 50 to 100 grams, are sometimes found in their stomachs; which, however, contain but little mercury.

The reactions in the *torta* commence at once after the magistral is added. It is said to work cold or hot. There are two kinds of heat: the first is due to an excess of the reagents; the second results from cold, and is called *calor de frio*. They differ as to their cause, but the result is the same, and increases the loss in mercury while it diminishes the extraction of the silver. On cold mornings, the heat of the pile being greater than that of the air, the pile steams; but as the sun rises higher this vapor ceases. This is called the *calor de frio*. When there is an excess of magistral, the chloride of mercury acts on the sulphide of silver and makes chloride of silver and sulphide of mercury—which latter is entirely lost. A large amount of heat is produced in this way. When the heat is thus caused by the excess of the reagent, wood-ashes or lime is added to decompose the chloride of copper which is formed. Lime or ashes are, however, never added when it can be avoided; they do not revivify the mercury, and they retard the operation and diminish the yield of both gold and silver. When lime is used, it should be in fine powder, and only just enough should be added to produce the effect. If large pieces of it were used, they would not be likely to be wholly acted on by the time the *torta* was right again, and their effect would have to be counteracted, as the

* Phillip's Gold and Silver, p. 341.

pile would become too cold. Tails, or any other sand free from soluble substances, can be used; but these are open to the objection that they increase the bulk without increasing the yield of the *torta*. When the heat is not too great, it can sometimes be cured by the application of cold water; but care must be taken not to add so much as to thin the pulp. Cold working means simply that the operation does not proceed quickly enough, and that an insufficient quantity of magistral has been added to the pile. If left in this state, a large quantity of mercury would be lost as oxide of mercury. To ascertain exactly what is to be done with the *torta* when in this state, assays of from 1 to 3 kilos., *ijadas*, are taken, and what is required added according to the indications which they give.

Many amalgamators prefer to work the *torta* rather hot. When it is manifestly too hot, they allow it to remain perfectly idle for a few days, taking assays all the time to ascertain when it gets back to the proper condition. They add nothing to the pile in the meantime, and when it has come back to its normal condition, go on as if nothing had happened. They think that they gain time and do not lose any more quicksilver than if they worked faster, and that they get a larger yield of the precious metals. In the winter season a little less sulphate of copper is required than during the summer. They generally begin to diminish the quantity of the reagent in September.

There have been a great many theories in regard to the action of these reagents, and a great many investigations of them, which can hardly be said to have cleared up many of the obscure points. A resumé of what has been done is given below, which, however, is not very satisfactory, and does not throw much light on the subject. Some of the published reactions, after careful trial, could not be obtained. The reactions given below have been compiled in the hope that some one may be led to make a more careful examination of the whole subject.

The amalgamators suppose that the chloride of sodium cleans the silver and the sulphate of copper heats it, and that the amalgam of silver and mercury results. The mercury lost is counted as lost mechanically; the amount of loss being about equal in weight to that of the silver extracted.

The generally received theory is, that the salt and the sulphate of copper act, the one on the other, and give rise to chloride of copper and sulphate of soda :*

$$CuSO_4 + 2\ Na\ Cl = Cu\ Cl_2 + Na_2SO_4.$$

The chloride of copper acts on the metallic silver and the sulphide of silver; chlorides of silver are formed, which are dissolved in the excess of chloride of sodium.

$$2\ Ag + 2\ Cu\ Cl_2 = 2\ Ag\ Cl + Cu_2\ Cl_2.$$
$$Ag_2\ S + Cu\ Cl_2 = 2\ Ag\ Cl + Cu\ S.$$

When mercury acts on artificially prepared chloride of silver, it reduces it to a metallic state, when it enters into combination with the mercury.

$$2\ Ag\ Cl + 2\ Hg = Hg\ Cl_2 + Ag_2\ Hg.$$

This reaction takes some time, and is less sensible on the natural than on the artificial substance.

If chloride of copper is treated with mercury, sub-chloride of copper and sub-chloride of mercury are formed.

$$2\ Cu\ Cl_2 + 2\ Hg = Cu_2\ Cl_2 + Hg_2\ Cl_2.$$

This reaction takes place more rapidly than with chloride of silver. If chloride of iron is substituted for the chloride of copper, all the reactions take place, but much more slowly, and this is especially true when sulphide of silver is present. The presence of salt accelerates the reactions in all cases. If any of the metallic silver in the ore has not been transformed into chloride, this is attacked directly by the mercury.

When sulphide of silver and mercury are shaken together, sulphide of mercury and amalgam are formed.

$$Ag_2\ S + 2\ Hg = Ag_2\ Hg + Hg\ S.$$

This reaction is slow but much quicker than with chloride of silver. All the sulphide of mercury is entirely lost.

Rammelsberg and Huntington have recently made the following investigations:† If sulphide of silver and chloride of copper are made to act on each other, either sub-chloride of cop-

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* Berg und Hüttenmännische Zeitung, 1881, p. 303.

† Die Metallurgie des Silbers und Goldes, von J. Percy, p. 12, Brunswick, 1881, and Min. Eng. Journal, Vol. 34, p. 150.

per, chloride of silver and sulphur are produced, or the sub-chloride of copper formed becomes a sulphide.

$$Ag_2 S + 2 Cu Cl_2 = 2 Ag Cl + Cu_2 Cl_2 + S.$$
$$Ag_2 S + Cu_2 Cl_2 = 2 Ag Cl + Cu_2 S.$$

The liberation of the sulphur is, however, a secondary reaction, taking place only to a very limited extent, thus:

$$Ag_2 S + Cu Cl_2 = 2 Ag Cl + Cu S$$
$$Cu S + Cu Cl_2 = Cu_2 Cl_2 + S.$$

When the solution is boiled for some time, the sulphur disappears and sulphuric acid is formed. The amount of sub-chloride formed, and of sulphur set free, is dependent on the strength of the solvent, which in this case is salt, on the temperature, and on the presence of air. The secondary reaction depends on the power of the solution to dissolve the chloride. If this could be removed, the solvent power of the solution would be to a certain extent regained. The action of the air in facilitating the secondary reaction is due to its converting the sub-chloride into an insoluble oxy-chloride.

$$3 Cu_2Cl_2 + 3 H_2O + 3 O = 3 CuO, Cu Cl_2, 3 H_2O + 2 Cu Cl_2.$$

If chloride of copper and sulphide of silver are boiled together the decomposition is complete.

$$Ag_2 S + Cu Cl_2 = 2 Ag Cl + Cu S.$$

When sub-chloride of copper and sulphide of silver are mixed, the following reaction takes place:

$$Ag_2 S + Cu_2 Cl_2 = 2 Ag Cl + Cu_2 S.$$

When one hundred parts of the sulphide of silver were treated with sub-chloride, in a solution of salt, as much as 7.6 or 8.3 per cent. of the silver remains dissolved in the salt solution. When the residue was treated with zinc, the following reaction took place :—

$$Ag_2 S + Cu_2 Cl_2 + Zn = Zn Cl_2 + Cu_2 S + 2 Ag.$$

When a salted solution of sub-chloride of copper is mixed with a saturated solution of chloride of silver in salt, no precipitation takes place, nor can it reduce chloride of silver when it is in powder. If sulphide of silver is added to the salt solution of sub-chloride of copper, chloride of copper, sulphide of copper, and metallic silver are produced.

$$Na\ Cl,\ Cu_2\ Cl_2 + Ag_2\ S = Na\ Cl,\ Cu\ Cl_2 + Cu\ S + 2\ Ag.$$

It thus appears, that while it cannot affect the chloride of silver, the sub-chloride of copper can reduce sulphide of silver, which, in the presence of mercury, is amalgamated without having passed into the state of chloride at all. If ammonia is added to the solution of the sub-chloride of copper and chloride of silver, silver is precipitated.

$$2\ Ag\ Cl + Cu_2\ Cl_2 + N\ H_3 = 2\ Ag + 2\ Cu\ Cl_2 + N\ H_3.$$

When chloride of silver, sulphide of copper, and ammonia are heated, a blue solution is obtained. One half the chloride of silver is converted into sulphide of silver. The residue, which is black, is composed of sulphide and chloride of silver, and contains no copper.

$$8\ Ag\ Cl + 2\ Cu\ S = \underbrace{Ag\ Cl + 2\ Ag_2\ S}_{\textit{Not Dissolved.}} + \underbrace{3\ Ag\ Cl + 2\ Cu\ Cl_2}_{\textit{Dissolved.}}.$$

Three parts of chloride of silver and two of chloride of copper remain in solution.

If two parts of chloride of silver dissolved in ammonia are treated with sub-sulphide of copper, a mixture of silver and sulphide of copper is precipitated, about one tenth of the silver still remaining in solution.

$$2\ Ag\ Cl + Cu_2\ S = 2\ Ag + Cu\ S + Cu\ Cl_2.$$

If four parts of chloride of silver are used, the copper remains almost entirely in solution, and 28.2 parts of the silver are also in solution. The residue consists of metallic silver and sulphide of silver.

$$4\ Ag\ Cl + Cu_2\ S = 2\ Ag + Ag_2\ S + 2\ Cu\ Cl_2.$$

Prof. Huntington found, that when chloride of silver and sulphide of copper are mixed in an ammoniacal solution, sub-chloride of copper is formed, which reacting on the chloride of silver forms metallic silver and chloride of copper.

$$2\ Ag\ Cl + Cu_2\ S + NH_3 = Ag_2\ S + Cu_2\ Cl_2\ N\ H_3.$$
$$2\ Ag\ Cl + Cu_2\ Cl_2\ NH_3 = 2\ Ag + 2\ Cu\ Cl_2\ N\ H_3.$$

The chloride solution for this reaction must be kept at a certain strength or the reaction will cease, and anything which causes further dilution will undo a part of the work already accomplished.

When chloride of copper and sulphide of arsenic are mixed, rapid decomposition takes place, and a precipitate of sulphide of copper and chloride of arsenic is formed.

$$As_2 S_3 + 3 Cu Cl_2 = 3 Cu S + 2 As Cl_3.$$

When chloride of copper and sulphide of antimony are mixed, a precipitate containing sulphur, copper, oxygen, chlorine and antimony is formed. Some antimony remains in solution on account of the sulphuric acid formed. When sub-chloride of copper is used, most of the copper is precipitated in the metallic state.

If proustite and pyrargyrite are treated with chloride of copper both are decomposed. All the silver of the pyrargyrite is converted into chloride, while only a part of that in the proustite is so acted on The reaction for proustite is

$$4 Ag_3 As S_3 + 12 Cu Cl_2 = 8 Ag Cl + 2 Ag_2 S + 2 Cu S + As_2 S_3 + 5 Cu_2 Cl_2 + 2 As Cl_3 + 5 S.$$

and for pyrargyrite

$$2 Ag_3 Sb S_3 + 4 Cu Cl_2 = 6 Ag Cl + Cu_2 Cl_2 + 2 Cu S + Sb_2 S_3 + S.$$

In both cases, part of the reagents remain in solution.

When sub-chloride of copper is dissolved in salt and boiled with pyrargyrite in powder, a black product is formed which contains most of the silver, all the antimony and sulphur, and some copper and chlorine; 7.3 per cent of the silver is dissolved by the salt.

$$2 Ag_3 Sb S_3 + Cu_2 Cl_2 = 2 Ag Cl + Ag_2 S + 2 Ag + 2 CuS + Sb_2 S_3.$$

When sub-chloride of copper and proustite are treated together, a gray product is formed which contains nearly all of the silver and sulphur, two-thirds of the arsenic, and considerable portions of the copper and chlorine.

$$6 Ag_3 As S_3 + 7 Cu_2 Cl_2 = 14 Ag + 4 Ag Cl + 12 Cu S + 2 As_2 S_3 + 2 Cu Cl_2 + 2 As Cl_3.$$

The proportion of the silver dissolved in the salt was 4.7 per cent.

If mercury, sulphide of silver, chloride of sodium, sand and water are worked together, seven-eighths of the silver present is extracted, three times as much as when the salt was not there. If oxide of iron is present in the mixture, chloride of iron will be formed, which is reduced to sub-chloride by the mercury, and a chloride of mercury is formed. A very small amount of oxide of iron produces a very considerable loss, as the sub-chloride constantly changes to chloride of iron, in contact with the air. If to this last mixture sulphate of copper is added, a little less silver is obtained, and the loss of mercury is large. If proustite, which contains 65.5 per cent. of silver, 15.1 of arsenic, and 19.4 of sulphur, is substituted for the sulphide of silver, twice as much silver combines with the mercury when chloride of copper is present. It requires a great deal of shaking to decompose the sulphide of silver. When sulphide of zinc is present with chloride of copper, it causes the formation of sulphide of copper and chloride of zinc, so that ores which contain blende always amalgamate badly.

From these reactions it would seem that, during the first two or three days, chlorides of copper and iron are produced by the action of the magistral on the salt; that chloride of silver is formed by the action of these chlorides on the easily attacked ores, and even on the sulphide of silver; that the chloride of silver is dissolved probably at once in the excess of salt. In chloridizing the silver, the copper and iron salts have become reduced to sub-chlorides, which in the presence of sulphide of silver form the chlorides, and produce metallic silver, or, when it is absent, quickly become oxy-chloride, and produce no further action. Sub chloride of copper reduces sulphide of silver; but the sub-chloride of iron does not. The presence of mercury prevents the formation of an excess of chloride of copper, for as soon as there is an accumulation of it, it acts on the mercury and is reduced to sub-chloride. Just as soon as the mercury is introduced the free silver is amalgamated; the chloride of copper which is still in the pulp forms calomel and sub-chloride of copper, which acts on the sulphide of silver and leaves it as metal, to be acted on by the quicksilver.

Some authors, especially Mr. Bowering, deny that chloride of silver is formed at all, as none was found in a torta left for four months on the patio, during which time he constantly examined the piles. Mr. Bowering says, in support of this theory, that when only two of the reagents, sulphide of silver, chloride of sodium, or sulphate of copper are mixed together, no effect is produced, and that when three are mixed in a small vessel, the mercury combined with just half of the chlorine in the chloride of copper, and formed sub-chlorides of both metals. As the chloride of copper has the property of absorbing oxygen, he concludes that it is the principal reagent. According to this theory the mercury acting on the chloride of copper makes sub-chlorides of both. The chloride of copper absorbs oxygen, which acts on the sulphide of silver and makes sulphuric acid, and leaves the silver in a metallic state to be absorbed by the mercury. The sulphuric acid set free acts on the chloride of sodium, and forms sulphate of soda. Chlorine is given off, combines with the sub-chloride to make a chloride of copper, which is again decomposed, and so on. In this case the sub-chloride acts just as nitric acid does in the manufacture of sulphuric acid. The action of the chemicals in the pile is especially slow if sulphide of silver is present, in which case the loss of mercury is also very large. When the whole of the silver is in the state of sulphide, a large part of it, which may sometimes be as high as 40 per cent., is lost. The mercury transforms the chloride of copper into sub chloride, which, like chloride of silver, is soluble in an excess of salt. The sub chloride in this state acts more energetically on the sulphide of silver than the chloride. A sulphide of copper is formed, while the silver is precipitated, and the chloride of copper formed again by giving up half the copper, which becomes a sulphide. This advantage is gained only at the expense of a very large quantity of mercury; and in order to prevent this loss, experiments were made of not introducing the mercury until much later in the process, but this did not succeed, as the extraction of the silver was not so well done.

The next day after the first treading, another one is made. The torta is then allowed to rest for a day, with occasional spadings, quite as much to make the mixture as to ascertain whether the ore is not getting too stiff from evaporation. As the heat of the sun is depended on for a part of the chemical action, water, when added, must be added in the morning, so as not to cool down the *torta* after it has once become heated, and thus disturb the reactions which are taking place. The pile must be trodden several times, the object being to keep renewing the surface of the silver which, without this, would become rapidly covered with a bed of solid amalgam which would prevent further action. The operation lasts from three to six weeks, according to the way in which it is conducted, the temperature of the air and the size of the heap. A succession of cloudy days or cold weather in the summer time will retard the operation. Continued or heavy rains may so thin the pulp as to prevent the reactions taking place, and stop all the working until the pulp thickens up again from evaporation. When all the conditions are the most favorable, the *incorporo* can be completed in 15 to 18 days. When they are unfavorable, it may take from 40 to 50 days. Taking several months together, 20 to 25 days will be the average time. In winter, when the *torta* always works slow, it may last as long as two or three months.

The day after the mercury is added, assays, *tentaduras*, are made, to see how the *torta* is working, to learn if any one of the reagents used is required, or if any of them is in excess. To do this, a probe-sample, which will weigh about 250 grams, is taken from as many different parts of the pile as possible. The assay is washed in a horn spoon or in an earthen plate, *platillo*, 0.18 m. in diameter, and 0.02 m. deep, a rotating motion being given to it. The lighter particles are carried off, and the heavier ones deposited on the bottom in the order of their gravity—the heaviest being in the centre. The mercury which has not yet acted, is generally in the centre, the silver-white amalgam, *ceja,* which, when moved, shows a distinct tail, *lista,* next to this, then the undecomposed black sulphurets, then pyrites, and generally a fifth ring of mercury in flour. Three assays are generally made on the *torta* each day, one in the morning before the work commences, one after the treading is about half done, and a third after it has been completed. During the first few days, the appearance of the mercury remaining unacted upon shows the workman what is taking place. The mercury is always more or less attacked. If during the first day it looks dull, is of a deep gray or lead color, there is too much magistral, and the *torta* is said to be too hot, and the temperature is really too high. A little lime is then added which decomposes part of the sulphate of copper and slackens the action. Lime is sometimes replaced by alkaline ashes. If on the contrary, the mercury is perfectly brilliant and not acted on at all, or is broken up into little globules, or if it is of a slightly yellow tinge, the *torta* is too cold, and more magistral must be added. It is always better to have too little than too much magistral; more can always be added, but too much means a loss of mercury. When the amalgam, *limadura de plata*, is in the proper condition, it is in thin scales, which are easily collected together into a mass of dry silver amalgam, *pasilla*, and mercury is easily pressed from it with the fingers. When it is very thin, so that it easily breaks up into fine globules, it is said to be *debil*, or weak. When it is hard and crystalline, and so dry that no mercury comes out from it when it is pressed, the amalgam is said to be strong, *fuerte*, and more mercury must be added. A dirty blackish appearance to either the mercury or amalgam indicates improper working. When the indications of color are all right, but the assay shows that no progress is being made, salt must usually be added. Sometimes this condition is only temporary, and is owing to a sudden reduction in the temperature of the air. Generally the defects are owing either to heat or to cold. Excessive heat always signifies a loss in mercury, and should be stopped as quickly as possible by adding cold water or ashes. If the heat is not excessive the *torta* may be allowed to stand a few days. Cold working is remedied by the addition of salt, or of sulphate of copper, or by additional treading. To ascertain which of these is required, careful assays must be made. Generally in the commencement, fresh ore or cement copper is used to correct the working, and toward the close cement copper, ashes, or lime.

When the amalgam is very fluid and easily breaks up into very small globules, and the assay shows that at least 75 per cent. of the silver in the pile is amalgamated, the torta is said to be finished or *rendida*. Sometimes the assay shows everything to be right, but no progress is made for several days in the amalgamation. This is usually owing to a want of salt, or to cold. If, on examining the black sulphurets, *polvillos*, and rubbing the small metallic globules of mercury or amalgam found among them with the finger, they unite to a large globule, the pile is nearly finished. If they yield a dry amalgam, it is not. The best way to ascertain this, is to make a fire assay of the original pulp and of the torta, and to judge by the yield. When the ores contain galena and blende, these substances decompose the chloride of copper, and the sulphur goes to the copper. The proportion of magistral to be added must, therefore, be largely increased, notwithstanding the fact that the loss in silver is always greater when there is an excess.

When the amalgamation is complete, a considerable quantity of mercury, in addition to that required for the amalgamation of the silver, is added, with the object of making sure the collection of all the mercury and amalgam. In some districts this additional mercury is called *baño*, The pile is still trodden for some time. This last addition of mercury has for its effect to make the amalgam a little more fluid, so that it may be collected more easily, and to collect the floured mercury which would not be caught in the subsequent washing, and to prevent as far as possible further action of the reagents on the amalgam.

There is always a loss of mercury equal in weight to that of the silver contained in the ore. A further loss of from 7 to 10 per cent. comes from that which is mechanically carried off either in the patio or in the washing. With such ores, 40 per cent. of the silver is often lost. The loss of mercury is often from 100 to 200 per cent. of the weight of the silver obtained. As a mean it is from 140 to 160 per cent. or 7 or 8 times the loss in the Freiberg barrel amalgamation process. The attempt was made to diminish this loss by adding a little iron, but in order that the effect may be sensibly felt, a large amount must be used, which increases the expense and does not diminish the loss much. In some of the works the mercury is replaced by an amalgam containing 30 per cent. of copper, which reduces the loss materially. The effect of the copper is the same as that of the balls of copper or iron which are used in the Freiberg barrel amalgamation process. Too much copper, however, must not be added, or it would make the amalgam of silver too friable. The loss in silver is increased by this method, but the loss in mercury is reduced to 120 to 150 per cent. The attempt was also made to use a lead or tin amalgam, but this was too viscous, and became easily reduced to powder, so that the loss in silver was increased.

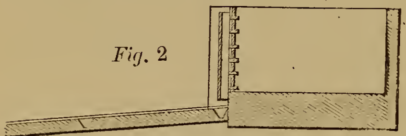
At the end of a time, more or less long, no mercury is found. The operation is nevertheless continued until the amalgam attains a certain consistence. If, however, the amalgam becomes too thick, a fresh charge of mercury must be made, adding it little by little. Sometimes the assays are made over only a small part of the torta. A little salt will be added in one part and a little magistral in another. Assays are then made to see the effect, in order to show what should be done with the whole pile.

When the *torta* is *rendida*, it must be washed as soon as possible, If allowed to stand, the sulphur and the sulphate of copper which have not been decomposed commence to act, and cause a considerable loss of silver in the state of very finely divided amalgam, *desecho*, which will not unite. It is to prevent this as much as possible, that the large excess of mercury is added, but notwithstanding the excess of mercury the pile must be washed at the earliest possible moment.

c. Separating the Amalgam.—The amalgam, with the excess of mercury, is scattered through a large mass of pulp, from which it must be separated by washing. This should be done once in twenty-four hours.

The washing, *lava*, is done in a box settler, *lavadero*, or in a tub, *tina;* both of these methods being in use in different works. The former is by far the most ancient. The tub, which is very much like the dolly tub or settler of California, has been in operation for many years, but as it requires the use of power, is only adopted in the large haciendas.

Fig. 2



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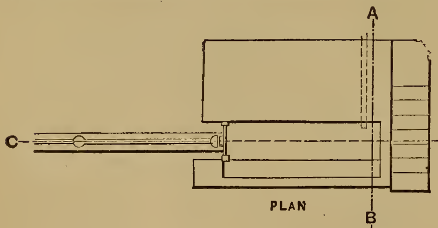

LAVADERO (Settler)
Scale 100:1
Fig. 3.

The box, *lavadero*, Figs. 2, 3, 4, is built of stone on the sides, and lined with cement. It is two meters long, half a meter wide, and one meter deep. It has a

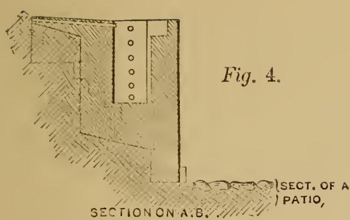

Fig. 4.

platform on one side on which to pile the material to be treated.

The front is closed with plank in which there are six holes, 0.05 m. in diam., five of which are closed with plugs of wood. These serve to let off the slimes. In front of these holes is a vertical wooden trough which carries the slimes to an inclined trough, the bottom of which is provided with several mercury traps to catch any mercury or amalgam that may be carried off.

The *lavadero* is built directly against the patio, the pavement coming up to its front wall. The material from the *torta* is carried to the platform of the settler by a pair of steps built on the platform side. The box is first filled half full with water. Two men then get into it, while one man on the platform shovels the ore into it. The men dance in the water, keeping it in motion with their feet, but keeping their hands out of it. The pulp and water are added little by little, the pulp by a single spadeful at a time, until the slimes flow out of the top hole, while the water is allowed to flow in only as fast as it flows out. The discharge falls down the vertical to the inclined trough, over the mercury traps and riffles, and goes from there to the settling tanks. The heavier liquid below is from time to time discharged by removing the lower plugs. The men are obliged to use a great deal of discretion at this work. If they work too fast, there is danger that some of the amalgam and mercury will be carried off. If they work too slow, the heavier particles collect at the bottom, and the small particles of amalgam sink through it slowly or not at all. They know by experience from the difficulty of moving their feet, when it is time to discharge through the lower holes. They never allow the lower part of the box to become filled. The amalgam is not removed until after the whole of the *torta* has been washed, then the supply of water being kept up, the plugs are removed one by one and the amalgam collected.

In some districts where wood is cheap, the tub is substituted for the stone box. The agitation in this is done with shovels or poles from the sides. No better results are obtained, but the labor is less severe. These box settlers can only be worked during the day, and must, on account of the danger that some one else may remove a part of the amalgam, be cleaned up every night. They cost but little to build, but require the labor of six men, treading, charging and bringing the pulp. As capital is scarce, but labor very abundant, the use of this settler is almost universal in Mexico.

Sometimes the washing of the *torta* is done in wooden tub settlers, *tinas*, which are usually driven by water power. They are from two to five meters in diameter, and one and a half to three meters deep. The shaft carries four arms, which are fitted with pieces of wood 0.06 m. square and 0.10 m. apart, which reach to within 0.30 m., or less, of the bottom of the tub. In the sides of the tub there are two holes, one 0.8 m. from the bottom, which is 0.15 m. in diameter, from which the tub is emptied; the other, 0.25 m. from the bottom, is 0.02 m. in diameter, and from it the water overflows, and the tail assays are taken. The axis is geared by wooden gearing to a water-wheel. These tubs were formerly constructed of stone. Three of them communicating with each other, were placed together, and were connected by one large wheel driven by two mules trained especially for the purpose. The first of these tanks, into which the pulp was put, was called *tina cargadora*, the third, from which the discharge was made, was called *discargadora*, or discharge tank. In some of the works these tanks are disconnected, though driven by the same power, each tank being used by itself. The tank is filled one-third full of water, and the axis is set in motion quite rapidly; when mules were used they were set at a full gallop, and a charge of 300 kilos. thrown in. Water is added until it reaches nearly to the top of the tub, and the speed reduced until it is just sufficient to keep the pulp off the bottom. In about an hour the assays taken from the top hole show that the mercury has all settled. The bottom plug is then removed, and the contents of the tub discharged into the settling tanks. This is a much better and quicker method of working. There is no danger of the tub becoming clogged at the bottom, and there is no necessity for constantly cleaning up at very short intervals. The tub can be kept going night and day until the whole *torta* is washed, without any danger of having a clean-up made by others. It will undoubtedly take the place of the box settler wherever there is sufficient capital to erect it.

When the whole *torta* has been washed, the *patio* must be carefully scraped, and also the interstices between the stones, to remove any particles of pulp, amalgam or mercury. All these scrapings, *raspadura*, are mixed with the last of the pulp, and are thrown into the settler. The time required to work depends on the number of settlers. It is usually not less than two or three days.

The tails from the *lavadero* or *tinas* consist mostly of iron pyrites mixed with the black sulphides and some ore, their proportion being different with the different ores treated. They are called *cabezilla* or *cabezuela*. They contain some amalgam which is recovered. Formerly* they were carried in wooden *bateas* to a tank filled with water, called the *pila apuradora*, On its surface a wooden bowl, *batea apuradora*, floats, which is from 1 m. to 1.50 m. in diameter. The man who washes with this *batea* leans on the side of the *pila*, and taking hold of the bowl with both hands gives it a peculiar motion, taking up a small quantity of water, which after going round the *batea*, is discharged, taking some of the *cabezilla* with it. The residues are treated on the patio. Generally the tails from the *tinas* and *lavadero* are run over riffled launders, where some of the mercury and amalgam is caught, into two tanks connected with each other, which for a *torta* of twelve to fifteen tons, are five meters long, three wide and one deep. These are called the *tanque* and *contratanque*. The object of the first is to catch all the heavy materials, such as the amalgam and the coarse particles of pulp. Most of the material containing silver and gold is caught here. The *contratanque* catches only the lighter particles, which are much poorer, and are always kept separate, unless found by assay to be of approximately the same value. The tails from the *contratanque* run to waste. The materials caught in both tanks are concentrated in the *chuza*, Fig. 1. Some amalgam, generally not less than 15 kilos., is caught here, the amount varying with the care that has been taken in the washing.

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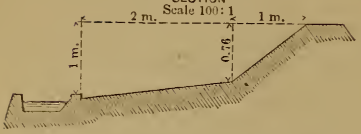
*Phillips' Gold and Silver, p. 344.

Fig. 5.

PLANILLA (Concentrator)
SECTION

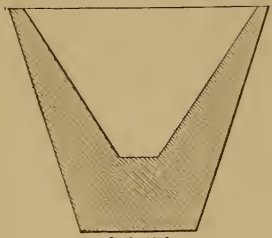


Width of Planilla 2 Metres

The tails from here are concentrated on the *planilla*,* Fig. 5, which is a platform of masonry from one and a half to two meters wide, and with a slope of one meter in ten towards the trough, which supplies a small stream of slowly-running water.† The wall at the upper side is sloped, and furnishes a space to pile up the tails to be washed. The workman, *planillero*, sits on a strip of board put across the water trough, and with a horn spoon containing about a quarter of a liter throws the water upon the pile of tails. The operation is commenced at the lower left hand corner, and continued across the *planilla*, going back again when the *planilla* has been crossed to the lower left hand corner, and working always in the same direction. The water is thrown in such a way as to spread out as much as possible, but not to splash. When this has been repeated several times, the sand for about one meter from the water-trough is thrown away. The heavy particles are thrown up on the pile, and the operation recommenced. When the supply of tails is exhausted others are added. The result of the washing is a small heap of black sulphurets, called *polvillo*.

Fig. 6 .

BOLICHE (Concentrating Bowl)
SECTION



Scale 20:1

These are further concentrated in a wooden bowl called a *boliche*, Fig. 6, which has the shape of an inverted truncated cone 0.62 m. in diameter, and 0.4 m. deep, which is a hand device in every way similar to the keeve used in dressing copper ores on Lake Superior,‡ and in the concentration of gold ores in California.§

The *boliche* is sometimes made as deep as 0.8 m., and correspondingly large, though this

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* Patio Process at St. Dimas. Trans, Am. Inst. Min. Eng., Vol. 11.

† Annales des Mines, 6th series, vol. 20, plate II, Figs. 5 and 6.

‡ Metallurgical Review, Vol. 2, p. 400. § Engineering, Vol. 31, p. 404.

is not usual. Water is put into the *boliche*, and the sulphurets added and stirred, and then allowed to settle. During the settling it is tapped on the outside with a stick or mallet. The heavy particles containing the sulphurets settle to the bottom, and the sand is on the top. The water is soaked off with rags. The sand is scraped off and thrown away. Below is a brownish layer of poor sulphurets called *colas*, which are removed to be roasted. Below them are the clean *polvillo* and a small quantity of amalgam. The *polvillo* is sent to Europe with the high grade ores for treatment. The roasting of the *colas* is done in an ordinary pile with a central chimney. It is put in layers 0.25 m. thick, and is used damp in order to be able to manage it better. The cover is made of earth. The pile is set on fire, and when the roasting is completed the half burned sticks are removed. Only a part of the material is properly roasted, but it is all ground in an arrastra and added to the *torta*. In some places where fuel is cheap, the roasting is done in a reverberatory furnace, and is consequently much better done. There is always great uncertainty in roasting in piles. This roasted material was formerly treated in a *torta* by itself; but it consumes a great deal of mercury, and does not give very satisfactory results. It is much better to mix it in the piles with the ore.

In some places, during the washing, a product is obtained which contains gold and silver, and though there is not much of it, it is richer in gold and silver than the original ores, and also contains some little amalgam. As the material is mostly pyrites, it is concentrated, ground and roasted, and used as a magistral. Sometimes 2 per cent. is obtained in this way.* Of late years, in some *haciendas*, all the tails of the different operations have been treated by the Von Patera process.†

4. Treatment of the Amalgam.

The liquid amalgam is carefully removed from the bottom of the settler. All that caught in the the mercury traps is added to it. This is carried to the mercury house, *azogueria*, and put

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* Eng. Mining Inst., Vol. 33, p. 104.

† Trans. Am. Inst. Min. Engs., June Meeting, 1883.

into a large trough, originally always of stone, but now often made of iron. When the whole has been collected, a large amount of mercury, usually ten to fifteen per cent. of the quantity of quicksilver used in the arrastra, is added to the amalgam in order to clean it. It is covered with water to prevent splashing, and carefully worked over. Whatever impurities rise to the surface are removed with a cloth, and fresh water is again added. This operation is repeated until the surface becomes and remains bright. The amalgam is dried and weighed, and is then put into a conical canvas bag, like those used in the West, which is called *manga*, set over a receptacle made of hide, *pila*, to catch the drippings, which, as they contain some little silver, are of more value in the next charge than pure mercury. This is put into flasks for preservation. The amalgam, free from every thing except mercury, *copella*, after hanging several hours, is ready for retorting.

At Chihuahua,* where very rich ores of native silver are treated, the amalgam looks like a coarse sand, but by the addition of mercury the dirt is removed from it. This dirt, however, is very rich, and is further concentrated. When particularly pure silver is required, it is carefully washed, and ground on a stone, in order to remove the sulphide of silver; the result is a very pure amalgam, which yields silver purer than fine bars. The amalgam cleaned with mercury is strained in canvas cloths, and the quicksilver pressed out into small balls 0.05 m. to 0.06 m. in diameter, by rubbing them with the hands. This is the only way they have been able to get very high grade silver.

Formerly, all the amalgam was beaten and pressed into an iron mould, to make bricks of amalgam, *bollos*, of such a shape that when six were placed together they formed a circular cake with a round hole in the centre. One ton of these was piled on iron supports, over a stone tank filled with water to nearly the top of a copper or iron bell, *capellina*,† which is 0.90 m. high, and 0.45 m. in diameter. This left a space 0.02 m. between the amalgam and the bell which was lowered to its place by pulleys. A wall of *adobes*, leaving a

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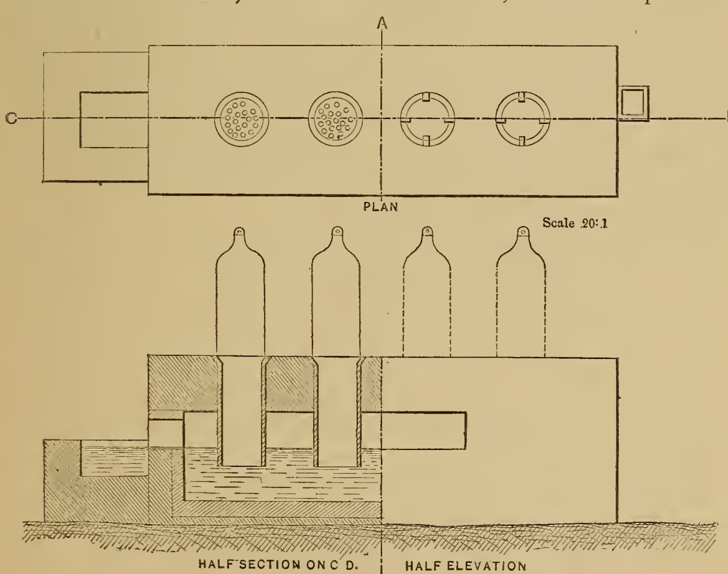
* Mining Commissioners' Report, 1872, p. 437.

† Annales des Mines, Vol. 20, Pl. 2, Fig. 2.

space 0.20 m. between the bell and the wall, was then built around it and fired with charcoal for fifteen hours, and removed when cold. The yield of silver was about 200 kilos., and the charcoal used about 250 kilos. per charge. This process is now abandoned.

In the more modern method, the strained amalgam is charged into quicksilver-flasks from which the bottom has been removed. Into these flasks others, open at both ends, are fitted so that the lower parts are beneath the surface of the water, in a tank placed under the furnace. The two flasks are luted so that the quicksilver has no outlet except into the water, where it condenses, as the screw in the upper part of the upper flask has been firmly set. The inside of the flask is then washed with milk of lime or lined with brown paper, to prevent the silver from adhering to the sides. To be sure that the amalgam fills the whole flask, it is first rammed in, and then pounded



QUEMADERO FOR RETORTING SILVER AMALGAM.

Fig. 8.

down with a heavy mallet. 30 to 35 kilos. are charged in each of the flasks, which are then set aside to drain off the excess of quicksilver, and to allow the amalgam to harden. As soon as 3 to 4 flasks are ready, they are taken to the retorting furnace, *quemadero*, Fig. 8, where they are set on end over holes on the slab which forms the bottom of the furnace. This slab is 0.60 m. above the ground. The size of the furnace is very variable, depending on the amount to be treated. It may have places for 8 to 10 retorts. The amalgam is kept in place by four narrow strips of iron set into the mouth of the flask, and bent so as to cross it beneath the amalgam. The space between the upper and lower flasks is covered with an iron plate full of holes 0.005 m. in diameter, which is luted to both the upper and lower flask. There is no danger of the amalgam falling out, except with an improperly managed fire. This furnace has entirely superseded the old *capellina*.

A wash of clay, about 0.005 m. thick, is put around the upper flasks to protect them from the air. A brick wall laid up temporarily is then built round all the flasks, and a charcoal fire is made inside of it. The first object of the fire is to dry the clay coating; it is therefore made to burn very slowly at first, so as to make it dry without cracking. When this has been done a brisk fire is made over the whole of the flasks. Water is kept constantly flowing into the tank below the flasks, both to keep up the supply and to keep it cool. The mercury driven out of the amalgam falls into the water and collects there.

The operation needs care. If the temperature is raised too high, there is danger of melting the amalgam. If raised too quickly, there is danger of explosion from the rapid formation of the vapors of quicksilver. If the heat is not high enough, the bullion is impure from excess of mercury. As a precaution against this, the purchaser has a right to heat the bars of silver red hot to drive off any excess of mercury, but if the bars melt while undergoing the process, the purchaser pays for them at their weight before heating. If they do not, the weight after heating is accepted. When the work is properly done, the silver still contains one per cent. of mercury. The mercury collected in the tank is not entirely free from silver, and must be strained. The amalgam collected is called *estrujon*, is much drier than the other amalgam, and is retorted by itself when enough has been collected to make it worth while to do so.

The retort silver, *plata pasta*, is refined in a small reverberatory furnace built of *adobes*, and heated with wood, which receives a charge of 300 kilos. of the crude bullion. This charge is refined in four hours. A little litharge and lead are added to remove the impurities, which are generally sulphur, arsenic, lead, iron, and sometimes zinc. Borax and carbonate of soda are used as a flux. The loss is seven per cent. of the crude bullion, and consists mostly of quicksilver, but to some extent of silver.

The silver obtained is quite pure: it contains at San Dimas .994 of silver, .0033 of gold, leaving only .0026 for base metals. At Chihuahua it is .998 from the arrastra, and .990 from the treatment of the tails.* The bars weigh 35 kilos. The slags from the refining furnace, with the tails from the tanks for washing amalgam, and other products, are occasionally smelted in a shaft furnace with the addition of galena, and the lead is used in refining retort silver.

The loss of mercury in retorting varies from two to six kilograms per ton. The total loss of mercury in Mexico has been for many years calculated on the supposition that it requires a loss of a unit of mercury for every unit of silver obtained. This being a fixed amount, is called *consumido*. Any amount above this which is not recovered is called *perdida*, or loss, and is always attributed either to carelessness on the part of the workmen, or to mechanical losses during the operation. The losses, both the fixed and the variable, are always referred to the Mexican *mark*, which is equal to 248.83 grams.

Consumido, - - - .	248.83 grams.
Perdida, - - - -	124.42 "
Total loss, - -	373.25

The loss of mercury for sulphuretted ores of from $60 to $100 will be, under the most careful management, not less than four to five kilograms. In some exceptional cases it has been three kilograms for every kilogram of silver extracted. The richer the ore the greater the loss. It may be averaged at one and a half kilograms for every kilogram of silver produced. With ores containing large amounts of native silver, the loss is proportionately much less, and sometimes even less in amount. The loss in

* Mining Commissioners' Report for 1872, p. 438, Washington, D. C., 1873.

silver varies from 20 to 25 per cent. of the assay value of the ore. Some amalgamators claim that they can save as much as 80 or even 85 per cent., but this is doubtful, even with the ores most easily treated. When the ores contain much blende and galena the loss easily reaches 25 to 30 per cent., and if in addition to this there is any amount of antimonial or arsenical sulphides, it will reach as high as 40 per cent. A part of this loss is, of course, counted with the loss of the amalgam, which is carried off in fine particles. It could easily be reduced by better appliances for catching the mercury, and better washing and concentration, to catch a larger part of the pulp not acted on. But there is a mechanical loss as well as a chemical one, which must in any case be large. Just as soon as it is possible to introduce all the modern methods of concentration, the conditions will be such that other processes will take its place. Although much has been done to improve it, no process with large losses in the precious metal and excess of labor, can hope to stand before increased facilities for transportatation. When gold is contained in the ore as a sulphide, not more than 40 per cent. is recovered; when it is free, 75 per cent. is often saved.* The cost of the process will of necessity vary in different localities under dissimilar circumstances, and with ores whose composition is not the same. The results vary from year to year. Phillips gives the mean cost per ton for reducing these ores as follows:†

Cost of Treating Ores.

Coarse crushing in dry stamps and subsequent fine grinding in arrastra,	$1.90	
Manipulation in patio,	4.50	
General expenses of management,	1.20	
Repairs,	1.20	
		$8.80
Sulphate of copper,	$3.20	
Salt (1.6 quintals per ton),	6.50	
Quicksilver (11 oz. per 8 oz. of silver),	6.50	
		$17.00
		$25.00

* Eng. and Min. Jour., Vol. 33, p. 104.

† Phillips's Gold and Silver, 1867, p. 357.

Mr. Rul* gives the cost in detail as follows, for a much more recent period.

COST OF GRINDING ONE TON OF ORE.

Mules,	$0.115
4 workmen,	0.148
1 mule-driver,	0.055
Repairs,	0.044
Night shifts,	0.208
	$0.570

COST PER TON OF WORKING TEN QUINTALS EACH IN THIRTY ARRASTRAS.

Mules,	$1.871
1 foreman,	0.142
1 helper,	0.077
3 feeders,	0.099
5 arrastra men,	0.219
3 watchmen,	0.132
3 men,	0.099
Bottom-stones,	0.116
Grinding-stones,	0.357
	$3.112

PATIO WORKING, PER *Repaso*.

Mules,	$0.029	
7 workmen,	0.021	
	$0.050	
14 repasos at 5 cents,		.70
Salt,		1.55
Sulphate of copper,		0.96
Labor,		0.17
		$3.38

SETTLERS AND DISTILLING.

Mules,	$0.082
Various expenses,	0.417
Charcoal,	0.066
	$0.565

* Eng. and Min. Jour., Vol. 33, p. 105.

GENERAL EXPENSES.

Salaries,	0.713
Rent,	0.274
Repairs and miscellaneous,	0.384
	$1.371

TOTAL COST OF WORKING PER TON.

Cost of grinding one ton of ore,	$0.570
Cost per ton of working 10 quintals in 30 arrastras,	3.112
" " " Patio working,	3.380
" " " settlers and distilling,	0.565
" " " salaries, rent, repairs, &c.,	1.371
	$8.998

This estimate takes no account of the mercury lost, estimating this at about $7.00. This would make a cost of $16.00, a much lower figure than that given by other authorities. Mr. Chism gives as the cost of working a $60 ore in ten ton tortas as follows:*

COST PER TON OF 2,000 LBS.

Breaking per ton,†	$1.53
Grinding,	1.40
Scraping arrastra to get out the gold amalgam,	.13
Carriage of slimes from arrastra to patio,	.60
Mules hired,	1.73
Labor, including driving and tending mules, spading and washing *torta*,	1.80
Salt at 6 Mexican dollars per *carga* of 98.3 litres,	2.80
Sulphate of copper at $0.25 (Mex.) per pound,	1.33
Charcoal for retorting and assaying at $0.37½ (Mex.) per *arroba*,	.33
Quicksilver at $0.62½ (Mex.) per lb.,	4.68
Salaries, general expenses, including keeping and feeding of mules,	6.66
Repairs,	2.33
Concentration of sulphurets,	2.26
Total,	$27.58

The expense of working with *tortas* of this size is much greater than if the pile were more than twice as large. When the *tortas* were of 19 tons and all the machines were driven by water power, the expense was as follows:

* Trans. Am. Inst. Min. Eng., Vol. 11.

† Breaking a ton of large ore costs $2.66, but as the smalls are also worked the average cost is as stated.

Cost per Ton of 2,000 lbs. in Working a *torta* of 19 Tons.

Breaking, grinding, and use of tools,	$6.66
Amalgamators' wages,	1.66
Scraping arrastra to get out gold amalgam,	.16
Carrying and washing scrapings,	.11
Concentrating tailings of "	.07
Carrying slimes from arrastra to patio,	.42
Mules and keeping,	3.72
Labor, spading and mule-driving,	1.60
" washing *torta*,	.56
Charcoal for retorting silver,	.47
Concentrating tailings of *torta*,	2.06
Materials, salt, 600 lbs at 8 cts.,	2.53
" sulphate of copper, 125 lbs at 25 cents,	1.65
" precipitated " 25 " 66 "	.87
" quicksilver, 133 " 62½ "	4.37
Total,	$26.91

There is not only a very great saving in doing the work by power, but in custom mills, to which these last expenses refer, there is a considerable profit included in the cost, which will not be less than from two to two and a half dollars per ton. It is astonishing how such a process has been able to retain its hold nearly three hundred years. In every country where it has been introduced, it, like many another historical process, has yielded before the advance of rapid means of communication, as this undoubtedly will in Mexico. It costs but little to carry it out, and it can be worked on a large scale as well as a small one, the latter having only this disadvantage, that it increases the loss. The process requires peculiar conditions of climate, which adapt it especially to hot countries. On account of the climatic conditions it has been abandoned in the West, where it was formerly used. It always works better on a hot day than on a cold one, in summer than in winter. The cheapness of the plant more than compensates for the time, as money in most of these countries is scarce, while time is of no value. Working the tails by the Von Patera process has, in some places, added to the yield in silver and increased the profits. The loss in reagents is easily put up with, as it is the only means by which the precious metals can be obtained. The method is only applicable to such ores as contain the silver native, or as chloride, bromide or iodide, associated as they usually are with highly oxidized substances. The presence of much sulphide renders the losses large. The process becomes difficult with the arsenio and antimonio sulphides, and impossible when there is much galena, blende, tetrahedrite, or bournonite in the ores. Not the least of the disadvantages of the process is the facility with which other people than the owners may make a clean-up, the only protection against this being the difficulty of selling unrefined silver, especially in small quantities. In very large works where much capital is invested, the item of time is a matter of consequence, but there seems to be no other process possible until transportation shall become less difficult.

THE CAZO PROCESS.

There seems to be no doubt that the *patio* process was in use in South America up to about the commencement of this century. It was still used there, to a very limited extent, until the year 1830, at which time it seems to have been quite generally given up, probably on account of the very large quantity of *negros* or sulphurous ores which began to be found. It was replaced in part by the Cazo, or caldron method, which is still in use there, and in some parts of Mexico, and partly by a new method in which the copper bottom was replaced by an iron one, and finally by still another process, which, while it imitated the pan amalgamation method so far as the machinery was concerned, added the chemicals which were supposed to form in the *Patio* already prepared. We shall briefly describe all these processes.

The *Cazo* process was invented in Chili, in the year 1609,* by a priest, Albaro Alonzo Barba, who, in his description of his own process, insists that the vessel in which the work is done should be made entirely of copper, though this was long since found not to be necessary. The ores to which this method is applied are the rich surface ores—chlorides, bromides and iodides, which, if they are not rich enough, must be concentrated on the *planilla*. The process yielded nearly the whole of the silver which is in them. The loss in mercury is from twice to two and a half times the total quantity of silver contained. The operation

* Percy's Metallurgy of Gold and Silver, Part I, p. 656.

lasted not much over two hours, and gave tails which did not contain more than $3 to $4 to the ton, but it was only applicable to ores which contain $80 and upward per ton, free from sulphur.

This process was formerly used in connection with the *patio*. The ores were first stamped and ground in the arrastra. This is done as a preliminary to a concentration. The grinding is not done so fine that there is danger of any large part of the silver being carried off in the washings. From the arrastra the pulp is carried to the *planilla*, where it is concentrated to such an extent that the concentrates do not represent more than two or three per cent. of the original ore. These concentrates are treated in the *cazo*, while the tails, if rich enough, were formerly treated on the *patio*. There are two processes known under the name of the *cazo*, distinguished from each other by the size of the vessel and the mechanical means of doing the work. The *cazo* is the smallest vessel. The larger one, constructed on exactly the same principle, is called a *fondon*. The process itself is very simple and rapid. It consists in boiling the concentrates, keeping them constantly agitated with salt and sulphate of copper, to which mercury is added, and then treating the amalgam.

The *cazo*, as originally invented, was a round vessel made entirely of copper, but was afterwards replaced by a vessel, at first made of stone, and then of wood, with a copper bottom turned up at the sides. This vessel was originally quite small. Its dimensions were: diameter above, 1 m; diameter below, 0.60 m.; depth 0.45 m. The thickness of the copper bottom was 0.05 m to 0.06 m. This was set over a fireplace without grate, bars or chimney, the smoke going out where the fuel was put in. A *cazo* of such very small dimensions could treat only about 50 kilos. at a time.

To treat the ore, water sufficient to make a thin pulp with the charge, was introduced. The fire was lighted, the water brought to a boil, and salt amounting to from 5 to 15 per cent. of the weight of the ore was then added. The workman then rubbed the bottom of the *cazo* with a piece of wood attached to a long pole, to keep the copper surface perfectly free. If the salt had been added before the ebullition of the pulp, it would have collected on the bottom, from which it would have been difficult to separate it. As soon as all the salt is dissolved, the first addition of mercury is made. This will generally be introduced in several portions; one quarter only being added at first. In ten or fifteen minutes an assay is taken, with an open horn attached to a long handle, so as to pick out the heavy parts of the ore and amalgam. This is washed, and if the amalgam shows itself as a clear gray sand, *polvo*, the charge is ready for the second addition of mercury. The same quantity as before is added, the heat and movement being kept up. In an hour or two after the start, another assay is taken, and another addition of mercury made, and so on until an amalgam containing two parts of mercury for one of silver results. The operation is then considered as finished. The amalgamator, *cazeador*, takes a last assay, *prueva en crudo*, which he washes to get out the gangues, then adds a large excess of mercury to dissolve out the amalgam, separates it from the tails, and then examines it by rubbing it against the sides of the vessel to see if any of the ores remain. If they do, the operation must continue; if not, and the amalgam remains fluid, it is stopped. At the end of six hours the operation is complete. The muddy material is run off into outside receptacles, and what remains in the *cazo* is dipped out, and treated in *bateas* with an amount of mercury equal to that which has already been used.

It is of the greatest importance, during the whole of the operation, to prevent anything from adhering to the bottom. If the salt was introduced before ebullition took place, it would collect on the bottom, and the apparatus would have to be emptied before it could be removed. It is more especially important to prevent any adherence of mercury, which would prevent the action of the salts of silver on the copper, and thus make the amalgamation progress very slowly. It would besides cause a great loss in mercury, as it alone, and not the copper, would reduce the silver salts. If the proportion of the mercury and silver are as two to one, no adherence of the mercury takes place.

The *cazo* was replaced by a much larger vessel,* 2.15 m. diameter above, and 1.80 m. below, and 0.85 m. deep, called a *fondon*.

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* Ann. des Mines, 6 s., Vol. 20, p. 216, Pl. III, Fig. 7.

The bottom is made of impure cast copper, and is 0.18 m. to 0.20 m. thick, 1.80 m. in diameter, and 0.18 m. deep. On the inside of the rim of the basin a place is cut out to receive the staves, which rest on the bottom of the cut made in the rim of the copper basin. These staves are 0.70 m. long, and are held in position by iron hoops. All the joints between the copper and wood are made tight with clay, and then adobes are built up around the whole to a thickness of 0.45 m. In the centre a raised space is provided for the pivot of the upright arbor which carries two arms, one 0.45 m. from the bottom, of a little less diameter than the interior of the *fondon*, and the other at 0.85 m., projecting beyond it for the purpose of hitching a single mule to it. The lower arm carries two pieces of copper, each of which weighs 140 kilos., which are used as mullers. They must be so arranged as to rub over the whole surface of the copper bottom to keep anything from becoming attached to it, as it would otherwise be impossible to grind with such soft materials as a copper muller. The whole is placed over a furnace with grate bars, on which the inferior fuel of the country is used. Such a *fondon* will last for ten years. The cost is*

60 quintals of copper for bottom, at $20, - -	$1,200
Two mullers, - - - - - -	120
25 staves at 3 reals, - - - - -	9
Furnace, - - - - - -	40
Wood-work for the mules, - - - -	10
House, - - - - - -	200
	$1,579

When everything is ready, the *fondon* is charged with 500 to 600 kilos. of rich ore, and 30 to 40 kilos. of the powder of unwashed ore, and sufficient water to form a thin mud. Fire is kindled on the grate, and the muller set in motion. At the end of two hours the material is boiling; 52 kilos. of salt, or about ten per. cent. of the weight of the ore, are added. This relatively large amount is necessary, as the success of the process depends to a great degree upon the quantity of salt used, and the velocity of the mullers. With the richest ores, the quantity of salt does not ex-

* *Ibid.*, p. 217.

ceed 25 per cent., and whatever may be the necessity for it, the number of turns of the muller will hardly exceed ten. About half the weight of silver contained in the ore is then added in mercury, and the mullers set in motion at the rate of ten turns per minute. The amalgamation commences at once. At the end of an hour an assay is taken from the bottom, taking care to take it ahead of the muller. If the amalgam washed out looks like light grey sand, it is composed of two of mercury for one of silver; the same quantity of mercury is again added, and at the end of an hour another assay is made, and so on, until the amalgam, even after it has been worked in the *fondon* for half an hour, shows an excess of mercury. The *prueva en crudo* is then made, and if any ore is found, the operation is continued half an hour without any addition of mercury. At the end of six hours the operation will generally be finished.

If there is an excess of mercury, there is danger that the sides of the vessel will be attacked; if there is no excess, but if the velocity of the muller is decreased, the copper and mercury become alloyed, and the bottom of the *fondon* becomes coated with a very thin coating of silver amalgam which is very difficult to remove. As the copper surface is much diminished, the operation is very considerably lengthened. There is also danger that the mercury will flour, and the loss in silver will be very great. There is only one remedy for this, which is to empty the *fondon*, and scrape the bottom clean. It is very easy to prevent this accident by adding the mercury carefully and in small quantities at a time, and by keeping up a uniform but rapid motion of the mullers. With these precautions, the work is very nearly independent of the skill and intelligence of the men. The results are quite uniform, and are obtained in a very short time.

As the reactions are not performed at the expense of the mercury, there is no occasion for any loss of it. If the operation is well carried out, all the mercury used should be collected at the end of the process; but this is never done. Some of it is floured, some of it volatilized, so that the loss is counted at about two per cent. The reason why there is such a small loss probably is that the work is done hot. The loss in silver is variable. The ores almost always contain sulphides more or less rich in silver, which are not acted on by this method. The tails vary from twenty-five to forty dollars to the ton, so that the *fondon* process can generally be used only as a preliminary method, and the patio, or some other process, is usually associated with it. The residues remaining in the fondon consist for the most part of the oxides of lead and iron, and some sulphurets containing silver and floured mercury. These are washed in large wooden bowls in a water-tight vat, adding as much mercury by weight as there is material to be treated, in order to collect the flour. The amalgam is treated as usual.

In Mexico, the slimes which have been removed are put into catch-pits where the excess of water evaporates. They are then made into small *tortas*, which are trodden by men. Two to two and a half per cent. of salt is added to them, but no magistral, for the water coming out of the *fondon* contains enough copper salts to do the whole of the work. The amalgamation is conducted as usual, except that it is very slow, lasting often as long as three months. The loss in silver is as much as 20 to 25 per cent. The mercury used is 125 to 150 per cent. of the silver contained. This method is one of the most rapid and least expensive of the Mexican processes. The cost is given below:*

Cazeador (amalgamator), - - - -	$0.500
Atizador (furnace man), - - - -	0.280
Wood for heating the furnace, - - -	1.562
Salt, 75 lbs., at $6 for 300 lbs., - - -	1.500
Mules, - . - - - - -	0.187
Mercury, two per cent., loss, - - -	0.416
Cost of distillation, etc., - - - -	0.250
	$4.665

In a single operation 1,200 pounds of ore are treated, which is 9.33 reals per charge.

If to these the expenses of dressing and concentration on the *planilla* are added, calculating the expenses in grammes of fine silver per ton, we have as follows:

* *Ibid.*, p. 221.

			Grammes.
Crushing with mule power,			17.360
" in arrastra,			57.860
Washing on the *planilla*,			17.360
Amalgamation.	Labor	34.720	
	Power	8.657	
	Fuel	72.313	
	Salt	69.443	
	Mercury	19.258	
	Distillation	11.573	
			215.964
Cost in grammes per ton			308.544

The very friable nature of the gangues has much to do with the small cost of the concentration. The cost elsewhere in grammes is:

	Grammes
Cost of extraction and sorting,	92.59
Transportation,	69.44
Treatment,	231.47
	393.50

This includes the cost of mercury, and shows a minimum for the metallurgical treatment. The treatment of these ores gives 400 grammes in the *cazo*, which pays the cost, the profit being in the treatment of the tails.

An attempt was made in Chili* to treat rich sulphurous ores with sulphate of copper and salt, but though it was a rapid process, and the tails were poor, the enormous losses in mercury caused it to be entirely abandoned. It was replaced by a method no longer used, but which is interesting as showing how another grew out of it.

The ores upon which the process is used are the rich bromides, chlorides and iodides of the upper part of the veins. The gangue is oxide of iron, the carbonates of baryta and lime, and some clay. They contain generally from $300 to $400 of silver to the ton. When such ores as these became rare, some other process had to be used. This method caused the almost complete abandonment of the Cazo process proper; and it was not until the ores became so very poor that it was no longer applicable, that it

* Revue Universelle des Mines, Series 1, Vol. 31, p. 489.

was replaced by the process now used in the vicinity of Copiapo. The ores were reduced to pulp by methods analogous to that in the *patio* process, from which this one originated. The pulp is carried away by a stream of water to settling-tanks 2 m. in diameter and 3 m. deep, made of sheet iron, the number in use depending on the size of the works. As fast as one of these settling-tanks is full, the stream is turned into another, and so on. The tanks, when full, are left from eight to twelve hours. The clear water above is then run off, and the mud below carried to the *tinas*. These are wooden tanks with cast-iron bottoms. They are 1.80 m. in diameter, and 1.20 m. deep. In the centre is an axis which carries a muller, which runs on or close to the bottom of the *tina*. This machine was undoubtedly suggested by the arrastra. The charge for each *tina* is one and a half tons of pulp. It is introduced into the *tina* while the muller is still. Mercury is added, to about twenty times the amount of silver contained in the ore, and the muller put into very slow motion, not over four times a minute. At the end of twenty hours the amalgamation was supposed to be completed. A stream of water was then introduced, and the light particles were thus carried off. When the water ran clear, the particles being too heavy to remain suspended in it, the mercury and amalgam were removed through a hole made in the *tina* for that purpose, and collected in a cast-iron vessel called a *cocha*. A complete operation, including the grinding, lasts about 60 hours. The cost for ores yielding $80 to the ton is $10 per ton, including the loss in mercury. The tails usually contain from $8 to $10 a ton. They are not allowed to contain more than from $25 to $30. As the ores themselves are very pure, the silver obtained is about .990 fine. So long as the ores were rich and pure, little was done to improve the process, but as they became poorer and more impure, the tails grew constantly richer, and it became necessary not only to treat them, but to treat the poor ores, *desmontes*, which had been thrown aside as not worth treatment. Barrel amalgamation was tried, but failed, as did also the attempt to chlorinize the ores and dissolve out the chloride of silver, as the ammonia cost too much. Recourse was then had to the abandoned *Cazo* process, which, with a number of modifications, proved successful.

The process which took the place of this* is a very simple one, applicable to all the ores of silver except argentiferous sulphides of copper, galena, or blende, and to ores which contain more than one per cent. of free arsenic, which causes great losses in the mercury. The inventor of it is not known, but it has been in constant use about Copiapo since 1862.

The ores must be carefully sorted, so as to separate them into different classes, keeping the especially rich ores by themselves, as these are worked much more rapidly than those of lower grade. The difference of time in the treatment of the different ores more than makes up for the trouble it costs.

The rich ores, including the sulphides, are treated in copper tanks with sulphate of copper, salt and mercury. The solutions are all made by steam, and beforehand, five per cent. of the weight of the mineral being added in salt. The sulphate of copper solution is made up to 20° B., and to it salt is added until no more will dissolve. The sulphate of copper is in this way transformed into chloride of copper, and the soda to sulphate of soda. When the liquor is saturated, it is decanted into large wooden tanks, and metallic copper, usually old copper sheathing, is put into the liquor, which is heated to ebullition by a current of steam at a pressure of three atmospheres. This causes the copper to be attacked, and a sub-chloride of copper is formed which is used in the process. The operation is finished when, by taking about 50 c. c. of the liquor and putting it into a liter of water, the oxychloride precipitates as a white powder, leaving the liquor colorless. The sub-chloride is then formed. The salt requires one vat, the sulphate of copper two, and the sub-chloride one, in their preparation. When the sub-chloride is formed it must be used as soon as possible, to prevent the formation of the oxychloride, and in order to do this as far as can be done, the solution is slightly acidulated with sulphuric acid.

A cast-iron Chilian mill, *trapiche*, each wheel of which weighs four tons, is used for grinding the ores. The bottom of the mill is called *solera*. This is usually made of cast-iron, but sometimes of steel. The mill turns at the rate of 10 to 12 turns a minute. The ore, which is ground sufficiently fine, is carried off by a current of

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* Revue Universelle des Mines, 1 Series, Vol. 31, p. 493.

water, the quantity of which is regulated according to the fineness to which the ore is to be ground. This water is made to pass through slime-pits five meters by two meters, and one meter deep, enough to run off perfectly clear from the last one. When one of the tanks is full, the stream is turned on to another. The full one is left for 8 to 10 hours. The clear water is then drawn off, and the pulp thrown out with shovels upon an area called *cancha,* to dry. When the ore is sufficiently dry, it is charged into barrels similar to the Freiberg amalgamation barrels. They are of different sizes, their capacity being from one to four tons, the larger the better. Those which hold four tons are 1.80 m. by 1.50, with a thickness of stave of 0.075 m. To the four tons of ore, enough of the salt solution is added to form a thick mud. The quantity of magistral to be added depends on the kind of gangue, much more being required for carbonate of lime than for clay or oxide of iron, as the former decomposes the sub-chloride. For an ore of about $80 to the ton, and a variable gangue, 28 to 30 litres of the magistral are added. The barrels are turned from twenty minutes to half an hour to make the mud quite uniform. Mercury amounting to from 20 to 25 times the quantity of silver contained, is then added. If there is a large amount of chloride or bromide of silver in the ore, twenty-five per cent of the weight of the silver contents of the ore is added in lead. This is amalgamated with mercury before it is introduced, and has for its object to prevent the formation of chloride and bromide of mercury, and a consequent loss. Lead is very easily attacked by the chlorine and bromine set free—much more easily than mercury. This saves the the mercury from being lost as chloride, and also prevents a mechanical loss, as the chloride of mercury, once formed, envelops the globules of mercury and prevents both their coming together in a mass and their action on the silver. Besides this, the mercury is much more easily reduced to a powder by this means, and is kept so, causing a great loss. This simple device of using lead reduced the loss in mercury, when the chloride and bromide ores were used, from 150 per cent. to 25 per cent. As soon as the mercury is introduced, the barrels are turned at the rate of four to five turns a minute for six hours. The operation is then complete. Water is added in considerable quantities, the barrel being turned for a short time, and the tails, amalgam and mercury discharged as in the Freiberg process. The amalgam recovered is not pure. It contains oxide of copper, produced by the action of the lime of the gangue on the chloride of copper, and the sulphides of copper produced by the action of the sulphate of copper on the sulphide of silver. These must be separated, the one by mechanical means, the other by chemical action. The first is done in a *tina*. The amalgam is charged with ten per cent. of fresh mercury. Water is added, and the muller is made to revolve at the rate of sixteen turns a minute. When the water which comes off is entirely clear, all the sulphide and a part of the oxide of copper will have been removed. To remove the oxide, all the water of the *tina* is run off, and two per cent. of carbonate of ammonia is added. The muller is revolved for five hours. At the end of that time it is stopped, and the amalgam washed with water. If this has been properly done no oxide will be left. The amalgam is distilled in a *capellina*. The mercury which is strained from the amalgam becomes little by little quite impure. After it has been used five or six times, it amalgamates very slowly. It is then purified by adding to it 20 grams of sodium amalgam for every 100 kilos. of impure mercury.

The resulting silver, *pina*, is refined in a reverberatory furnace. It contains some arsenic, which is extracted by the iron of the tools, and floats on the surface of the bath and is removed. The method of refining does not differ in other respects from that used elsewhere. The silver obtained is 980 fine. By this process, tails which do not contain more than $6 to $8 to the ton, and ores of from $10 upward, are worked. When the ores do not contain more than $80 to the ton, the tails do not contain much more than two to three dollars. Plenty of good water is a necessity for such works, both for purposes of washing and for power if possible.

To treat eight tons of ore in twenty-four hours, requires an area of 500 square meters for the ores, and one of 1,000 square meters for drying the pulp; two Chilian mills requiring about six horse-power; two settling tanks, and two amalgamation barrels requiring about eight horse power; a vat to collect the water from washing the barrels, to recover the floured mercury; one trough for washing the amalgam; one distilling furnace; one reverberatory furnace for refining the silver; a tank for the preparation of the magistral, with a three-horse power boiler attached; two vats for dissolving the sulphate of copper; a vat with hydraulic cement to make the salt solution, with a boiler for boiling it; a syphon for clarifying the liquors, which must all be treated with lime to precipitate the copper contained in them ;—these constitute the machinery and apparatus for the works. The cost of treating a ton of ore of about $40, not including interest nor sinking fund, would be—

Crushing, - - - - - -	$1.60
Mercury, magistral and salt, - - - -	4.00
Purifying the amalgam, - - - -	.04
Distillation, - - - - - -	.04
Fusion and firing, - - - - -	.09
Various expenses - - - -	1.00 to 1.10
	$6.87

The whole operation is very simple,—quicker, and with less loss, than the barrel, more certain in its reactions than the *patio*, and applicable to almost all the ores found in Chili. It is even cheaper, under some circumstances, than the lead fusion.

Glossary of Terms Used in this Article.

Adobes,	Sun-dried bricks.
Arrastra,	Mexican mill for grinding ore.
Arrastra de cuchara,	A spoon *arrastra.*
Arrastra de marca,	A large *arrastra.*
Arrastra de mula,	An *arrastra* worked by mules.
Arroba,	Mexican weight of 40 lbs.
Atizador,	Furnace-man.
Azogue,	Quicksilver.
Azogueria,	The mercury-house.
Azoguero,	The amalgamator.
Baño,	Excess of mercury used in the *torta.*
Batea,	A bowl.
Batea apuradora,	Wooden bowl floating on the *Pila apuradora* to receive the *cabezilla.*
Bolichar,	Treatment in *boliche.*
Boliche,	Bowl for concentrating.
Bollos,	Triangular bricks of amalgam.
Bonanza,	Rich pocket in a vein.
Cabezilla,	Residue after washing the *torta.*
Cabezuela,	Concentrates rich in gold and silver.
Cajetes,	Walled receivers for the ground slimes. (See *lameros.*)
Caliche,	Feldspar.
Calichoso,	Feldspathic.
Calor de frio,	Steam caused by the difference between the heat of the pile and of the air.
Cancha,	Space for drying slimes.
Capellina,	Bell covering *bollos* while distilling off the the mercury.
Carga,	Mexican weight of 300 lbs.
Cazeador,	Amalgamator.
Cazo,	A vessel with a copper bottom, for heating and amalgamating the ore.
Ceja,	Silvery-white amalgam.

Chuza,	Washer or settler.
Colas,	Brown sulphurets above the *polvillo* in the *boliche.*
Cocha,	A cast-iron vessel.
Colorados,	Colored ores containing silver.
Comalillos,	Calculation furnaces for making magistral.
Consumido,	Fixed loss of mercury.
Contratanque,	Second settling-tank.
Copela,	Dry amalgam in bag after draining.
Copelilla,	Zinc blende.
Cuchara,	A hollowed spoon-shaped float on the arrastra.
Debil,	Term applied to amalgam when very fluid.
Descargadora,	Discharging tank, from which the slimes are run off last.
Desecho,	Broken-up mercury. The attacking of the amalgam by the sulphur, etc., causing loss of silver.
Despoblado,	Ore with much gangue,
Desmontes,	Poor ores.
Ensalmorar,	The addition of salt.
Estrujon,	Amalgam strained from the mercury collected in the basin of the furnace.
Estufa,	Stove for evaporating the mercury from the amalgam.
Ferro blanco,	Arsenopyrite.
Fondon,	A large *cazo.*
Fuerte,	Strong; applied to amalgam needing more mercury.
Galeme,	Lead cupellation furnace for silver.
Galera,	A long shed on each side of the *patio.*
Granza,	Coarse sand from stamping-mill.
Granza de llunque,	Third class ore.
Guija,	Quartz.
Guijoso,	Quartzose.
Hacienda,	Establishment for treating ores.
Ijadas,	Assays of two to five pounds.
Incorporo,	Mixing the magistral and mercury in the *torta.*

Insalmoro,	Salting the *torta.*
Jicara,	A small vessel or bowl in which the assay sample is washed and the amalgam tested.
Jales,	Tailings.
Lagune,	A small lake.
Lama,	Slimes.
Lameros,	Slime pits; walled receivers for the ground slimes. (See *cajetes.*)
Lava,	Washing the *torta.*
Lavadero,	The ordinary settler; washing apparatus.
Limadura de plata,	Dry silver amalgam.
Lista,	Tail of impure mercury.
Magistral,	Roasted copper pyrites, sulphate of copper, etc., used to reduce silver ores in the torta.
Manga,	Canvas bag to drain amalgam.
Marc,	Mexican weight for weighing silver and gold, eight ounces.
Marmajas,	Concentrated sulphides.
Metal calichoso,	Feldspathic ore.
Metal de beneficio,	Second class ore worked on the *patio.*
Metal de exportacion,	First class ore ready for sale.
Metal hecho,	Hand-picked rich ore.
Metal de primera clase,	First class ore ready for sale.
Metal gabarro,	First and second class ore, from the size of an egg to that of an orange.
Metal granza,	Fine ore, smalls.
Metal de labores,	Smalls from the workings of the mine.
Metal de llunque,	Smalls from the cleaners.
Monton,	Mexican weight varying from .75 to 1.62 tons.
Molino,	Stamp-mill for ore.
Morteros,	Stamping-mills.
Negros,	Black ores of silver.
Oroche,	Bullion after retorting.
Pasilla,	Dry silver amalgam.
Patio,	Amalgamation court.

Perdida,	Loss of quicksilver beside the *consumido.*
Pila,	A trough of hide.
Pila apuradora,	Tank to receive the residues from the washing-tanks.
Pina,	Retort silver.
Planilla,	Inclined platform to concentrate tailings.
Planillero,	Operator on *planilla.*
Plata,	Silver.
Plata cornea amarillia,	Iodyrite.
Plata cornea blanca,	Kerargyrite.
Plata cornea verde,	Embolite.
Plata mixta,	Alloy of gold and silver.
Plata negra,	Argentite.
Plata pasta,	The spongy bars of silver after retorting.
Plata piña,	Silver after retorting.
Plata verde,	Bromyrite.
Platillo,	Earthen plate for testing the slimes.
Plomo,	Galena.
Polvillo,	Rich black sulphurets left on *planilla.*
Polvo,	Fine grained amalgam from *cazo.*
Precipitado,	Metallic copper precipitated by iron or zinc.
Prueva en crudo,	An assay from the *cazo.*
Quebradero,	Breaker or crusher.
Quemadero,	Distillation furnace; retort.
Quemazon,	Black decomposed ore.
Quintal,	A hundred pounds.
Raspa,	That portion of the precious metals obtained by scraping the arrastra, or the patio.
Raspadura,	Scrapings.
Raspando,	Scraping; removing the amalgam from the arrastra by scraping.
Relaves,	Material remaining after the washing of the *tortas.* (See *polvillo.*)
Rendido,	Term applied to *torta,* when the amalgamation is concluded.
Repaso,	Treading of the ore in the *torta.*

Rosiclara,	Ruby silver.
Saltierra,	Impure salt from lagunes.
Solera,	Cast iron bottom of a Chilian mill.
Tahona,	A spoon arrastra.
Tahonero,	Man in charge of the *tahona* or *arrastra.*
Tanque,	First settling-tank.
Tentadura,	Assay.
Tierras de labores,	Smalls from the workings of the mine. (See *Metal granza de labores.*)
Tierras de llunque,	Smalls from the cleaners. (See *Metal granza de llunque.*)
Tina,	A circular tank; a round dolly-tub.
Tina cargadora,	Tank into which the slimes are first discharged.
Torta,	Heap of slimes on the *patio.*
Tosa,	Grinding-space in the *arrastra.*
Trapiche,	Chilian mill.
Trilla,	Heap of slimes on the *patio.* (See *Torta.*)
Voladora,	A muller.
Voltear la torta,	Spading: turning the *torta.*

II.—*Upon a Fourth Monobromphenol.*

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Translated by Prof. Frederick Stengel, New York.

Read December 3d, 1883.

In spite of the circumstance, that besides the previously* prepared isomeric nitrobenzoic acids, there have been obtained, in the year 1881, by myself, two new mononitro-phenols,† the very existence of which is altogether inconsistent with the adoption of Kekulé's benzol-hypothesis, the adherents of this hypothesis insist upon taking up a position in regard to the new facts of a purely negative or silent character; and Kekulé himself, who had not yet published any investigations of his own in opposition to mine, declares in his Manual‡ that I had discovered the new nitrobenzoic acids by peculiar artifices, which consisted essentially in my avoiding with much care all methods of verification adopted by other chemists.

However weighty this reproach may be, when it comes from one who is looked upon as the first authority on the subject of the chemistry of aromatic compounds, every man free from prejudice must, after having actually perused my treatises, become convinced that in truth this reproach is undeserved. For, as we all know, no conclusion can be correct if the premises are false, and the statement of the use of "peculiar artifices, etc., has as yet never been proved by any one. The progress of science has always brought along methods that may appear to be artifices.

Nobody will deny that cyanate of ammonia is different from urea, though the "artifice" of preparing the former consists

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* Journal f. prakt. Chem (2), 17, 184.

† The same (2), 24, 1.

‡ 1881, Vol. 2, 304.

simply in the exclusion of water; that accordingly it could also here be said that cyanate of ammonia did not exist. So, too, according to the usual method (by means of hydrochloric acid in an alcoholic solution), or also, from its silver-salt, by ethyl-iodide containing iodine, malæic acid* does not give its characteristic ether, but that of fumaric acid, while malæic acid-ether is formed only where special precautions are taken, and so forth. These are facts which are undisputed, and quite analogous to those discovered by me.

In the following, however, I believe I have furnished new proofs for maintaining in good faith the existence of chemically pure substances derived from benzol, which are not possible according to the benzol-hypothesis. This time the methods of preparation are also less difficult than before, and special "artifices" of treatment are not needed. We may therefore be confident that we can convince ourselves, with less trouble, of the correctness of my results.

The new compounds prepared by me, are a *fourth monobromphenol* and its derivatives. In regard to the new nitro-derivatives of benzol, it might have been concluded, though on insufficient evidence, that the isometry of benzoic acid, in respect to its phenol derivatives. was to be traced back to a different structure of the nitro-group NO_2 itself. It was therefore important for me to prepare adequate new derivatives of benzol, of which, from the very beginning, the structure of the "lateral series" could not be discussed. Such bodies are the halogen derivatives of phenol, and therefore, after very wearisome and lengthy experiments, not having succeeded in preparing a new iodophenol, I endeavored subsequently, and with success, to obtain a fourth monobromphenol. Moreover, I had already proved the existence of a fourth oxybenzoic acid.†

In what way the investigations made hitherto concerning the equivalence of the benzol-hydrogen, or the internal arrangement of the atoms in the benzol-molecule, will stand criticism, I have discussed before.‡ Meanwhile, new facts have come to my

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* Jahresb. d. Chem., 1878, 713; 1879, 633.

† The same, 1878, 757.

‡ Journal f. prakt. Chem. (2), 17, 428, etc.; (2), 24, 2.

knowledge which confirm my views. Menschutkin* explained already, in 1877, when speaking of his experiments on the formation of ether, that aromatic compounds behave simply like "non-saturated" compounds; hence there could not be the question of a specially-constructed "main substance. Brühl,† in his treatise on the "thermal and optical properties of liquid organic compounds," arrived at the conviction that the so-called "double bonds" of the hydrocarbons do not signify a more intimate, but, on the contrary, a weaker attraction of the atoms in respect to the simple chain—an explanation which, in the first place, must put in question the constitution of benzol according to the prevailing opinion.

Goldschmidt‡ recognized, in his investigation upon the action of "molecular" silver upon carbon-chlorides, that the affinities of carbon are *not equivalent*—results with which my own investigations are in perfect harmony.

To what monstrosities in general the upholding at any cost of the benzol-hypothesis may lead, Schoonmaker and Van Mater§ have but lately shown. Because the formation of their isomeric fluid p—dibrom-mononitro-benzol from p—dibrombenzol, cannot be harmonized with the hypothesis, they suppose, in a simple nitration, a so-called atom-wandering within the molecule, and determine also most accurately (p—dibrom-mononitro-benzol being converted by sulphuric acid into the liquid isomere), that this atom-wandering could only take place after the introduction of the nitro-group. To seek to support a hypothesis with such forced suppositions, can under no circumstances be of any advantage to it.

Every advance of science consists, generally, in a simplification of the fundamental ideas. So it was in abandoning the notions about the philosopher's stone, the tartarus, the alkahest, phlogiston and the vital force. And so, likewise, when the belief in the equivalence of the carbon-affinities is completely abandoned—as we may expect in not too long a time—not a

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* Jahresb. d. Chem., 1877, 323.

† The same, 1881, 1108, etc.

‡ The same, 1881, 375, etc.

§ The same, 1881, 541.

complication, but a simplification of the chemical notions will be manifest.

Isomeric Monobromphenols.

Hübner and Brenken* have been the first to prepare a crystalline monobromphenol from phenol, in a glacial acetic acid solution with bromine, as well as also from β—brom-salicylic acid. They gave its melting-point from 63° to 64° ; its boiling-point, 235° to 236°.

Fittig and Mager† gave to this product the boiling-point of 238°, by identifying it with a body which they obtained, from p—bromnitro-benzol. Hereby was, at the same time, in the sense of the benzol-hypothesis, this bromphenol characterized as a paraderivative, especially as, by melting it with potassic hydrate, it passed over into resorein (formerly considered to be p—dioxybenzol.) Körner‡ prepared this (para) bromphenol from common nitroacetanilid, and gave its melting-point 66.4°, while Fittig and Mager§ retained the one previously found (64°). These‖ described, also, the isomeres, o—brom and m—bromphenol, the former as a body of the boiling-point, 194° to 195,° which, when cooling, does not solidify ; the latter having a melting-point of° 32 to 33°, and a boiling-point of 236° to 236.5°.

Körner¶ obtained, further, from p—bromphenol a monobromdinitro-phenol of the melting-point 75.6° ; from o—bromphenol, a monobrom-dinitro-phenol of the melting-point, 118.2° (previously prepared by Laurent) ; from m-bromphenol, besides other products, a monobrom-dinitro-phenol melting at 91.5°. A monobrommononitro-phenol of the melting-point, 88°,** was likewise prepared from p—brom-phenol by Körner.††

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* Jahresb. d. Chem., 1883, 409, etc.

† The same, 1874, 461.

‡ The same, 1875, 336.

§ The same, 1875, 417.

‖ The same, 1875, 416, 417.

¶ The same, 1875, 335, 336.

** Brunck, Jahresb. d. Chem., 1867, 618.

†† Jahresb. d. Chem., 1875, 336.

Very interesting and important, as an illustration to my own experiments, is the fact that, according to Fittig and Mager,* all the three mentioned bromphenols, by melting with potassic hydrate (besides some pyro-catechin) form chiefly resorcin (m—dioxybenzol.) We shall see, that also, the new isomere prepared by me forms no exception to this behavior.

For the preparation of a fourth monobromphenol, I tried at first by a method analogous to that used in the preparation of the new isomeres† formerly discovered by me, to let bromethyl act on phenol. I had, however, to learn that such action was of no practical value, and if ever it took place the process was very slow. The reaction succeeded better when I prepared synthetically the bromethyl in a mixture with phenol, by adding bromine to the alcoholic solution of the latter, after having introduced a corresponding quantity of amorphous phosphorus. Finally an accident taught me that the amorphous phosphorus was not only superfluous for the reaction, but unprofitable.

Accordingly, I first prepared the fourth monobromphenol according to the following method; afterward, however, I omitted the amorphous phosphorus from the mixture that was in other respects the same.

Fourth Monobromphenol.

Ten gr. phenol are dissolved in 10 gr. absolute alcohol; then mixed with 3 gr. amorphous phosphorus, and then 17 gr. bromine are added, through a funnel-shaped capillary tube, cooling at the same time with cold water. Without the application of the capillary tube, even when the bromine is poured in by drops, a very violent reaction takes place, with a considerable elevation of temperature, which prevents the formation of the new body. It is expedient to see that the temperature of reaction does not exceed 20°; with reference to which point, however, I may observe that I have never noted the formation of an isomeric bromphenol, even at a somewhat elevated temperature. After having worked for some time according to this method, I forgot

* Jahresb. d. Chem., 1875, 416, etc.

† Journal f. prakt. Chem. (2), 17, 184; (2) 24, 1.

on one occasion to use the phosphorus in the reaction, whereby, to my great surprise, I did not obtain smaller but larger quantities of the fourth monobromphenol. I therefore retained in the future the above method, but without the addition of phosphorus; and also, as it proved practical, I used in my work the above-mentioned small quantities of the substance only, or the double quantity at once. After completing the operation, the raw product is poured into water; the separated oil is washed with water and a weak solution of carbonate of soda, then with water again, and then dried and rectified. The following observations were made concerning the distillation:

Up to 195° very little was distilled. That which boiled between 195° and 205° solidified in a freezing-mixture of ice and common salt, partly; that which boiled between 205° and 210°, completely; the remaining fractions, however, 210° to 225°, 225° to 235°; 235° to 238°, and 238° to 240°, did not solidify. Above 240° nothing distilled; from the residue in the jar, however, there could still be obtained, by distillation with aqueous vapor, a thick yellowish oil, which curdled gradually at a low temperature.

From the fractions, 235° to 238°, and from 238° to 240°, which behaved in precisely the same manner towards nitric acid, I was able, by a repeated careful fractioning—that is, in small portions—to separate the *fourth monobromphenol* of the boiling-points 236° to 238°. The same cannot be distilled in a pure state without decomposition, nor can it be rectified in large quantities. In an experiment to rectify, with the usual pressure, about 200 grammes of raw product, of the boiling-point 225° to 240°, the total quantity was entirely decomposed, with the evolution of large quantities of hydrobromic acid and a plentiful separation of coal. The product, distilled over in small portions between 236° and 238°, gave the following analytical data:

(I.) 0.2989 gr. of substance furnished 45.79 per cent. Br.

(II.) 0.3144 gr. of substance furnished 41.10 per cent. C and 3.41 per cent. H.

(III.) 0.3325 gr. of substance furnished 41.14 per cent. C, and 3.16 per cent. H.

(Calculation for $C_6 H_4 \frac{OH}{Br}$. C, 41.62 per cent.; H, 2.89 per cent., and Br., 46.24 per cent.) According to this, the body is actually a monobromphenol. It must be specially mentioned that combustion takes place only with difficulty, in consequence of which, a little tube drawn to a point is not available. It is necessary to mix carefully the liquid substance with the chromate of lead itself, and afterwards to burn it by means of oxygen. The boiling-point of the new bromphenol is according to the above, [230°], the same in fact as that of the p—bromphenol; but it differs from this physically, as it cannot be solidified at a temperature of —10° to —12°, while para-bromphenol is a solid body, melting at 64°. It is, moreover, nothing new that bodies chemically different manifest the same boiling-points. This is, for instance, the case with the toluidines as well as the isomeric chlorphenyloic oils,* and an example of the same melting-point of two isomeres is found in the dinitro-toluidines.† Moreover, the boiling-points of meta- and para-bromphenol (see above) differ only two degrees—a difference that cannot be of any consequence.

In the following I shall, however, describe the behavior of the fourth monobromphenol towards nitric acid, which is entirely different from that of p—bromphenol (which is here the first point in question), as well as from that of the other isomeres.

Nitro-compounds of the Fourth Bromphenol.

As above already briefly mentioned, Körner‡ obtained a monobrom-mononitrophenol from p—bromphenol, which proved to be identical with that obtained by Brunck§ by tho action of bromine upon nitro-phenol. It melted at 88°. From the same bromphenol, the former prepared—by using more nitric acid—‖ a monobrom-dinitro-phenol of the melting-point 75.6°. By means of the bromphenol obtained by Hübner and Brunken,¶

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* Jahresb. d. Chem., 1879, 349; 1880, 627.

† The same, 1881, 543.

‡ The same, 1875, 336.

§ The same, 1867, 618.

‖ The same, 1875, 336.

¶ The same, 1873, 409, etc.

Armstrong and Brevost* received as main product a monobrom-dinitro-phenol that melted at 78°, and which accordingly may fairly be considered identical† with the above prepared by Körner. The latter‡ prepared besides, from m—bromphenol, an isomeric monobrom-dinitro-phenol of the melting-point 91.5°, which he likewise obtained§ from a dinitro-dibrom-benzol by the action of potash-lye: o—bromphenol gives, according to Körner,‖ as the only product of reaction with nitric acid, the brom-dinitro-phenol obtained before by Laurent from a dinitrophenol with bromine, and to which Körner gives the melting point 118.2°. Surely the very same body has also been prepared by other investigators, and described‖ with the melting-point 117°,¶ 115°,** and 116°†† respectively.

None of the above nitro-derivatives will form if the nitration of the new bromphenol is made according to the method employed by Körner (in a solution of glacial acetic acid).

If one part of bromphenol is dissolved in about three parts of glacial acetic acid, and this solution is dropped into nitric acid of 1.4 specific gravity, which is kept constantly cool, an oily mass is first obtained. This, on being put in a cool place, solidifies gradually. This combination is a *molecular combination.* It is true that it can be once recrystallized from alcohol for rectification, but by a continued treatment with it, especially boiling for some time, it decomposes into different nitro-products, according to conditions which I did not follow up more closely. After one careful crystallization from warm (not boiling) alcohol, it melts at 60° to 65°. For combustion, such a product gave the following numbers :—

0.3516 gr. furnished 29.34 per cent. C, and 1.90 per cent. H. A body of the formula $C_6 H_3 Br (NO_2) OH. C_6 H_2 Br (NO_2)_2 OH.$

* The same, 1874, 461, etc.

† According to another communication (Jahresb. d. Chem., 1875, 339)] however, the melting point of these bodies is equal to 85.6°.

‡ Jahresb. d. Chem., 1875, 335.

§ The same, 1875, 340.

‖ The same, 1875, 335.

¶ The same, 1874, 461 and 467.

** The same, 1873, 411.

†† The same, 1875, 427.

would have to furnish 29.93 per cent. C, and 1.45 per cent. H. Accordingly, we have a molecular compound of *monobrom-nitro-* and *dinitro-phenol.* In spite of the somewhat low numbers for carbon and the single analysis, I must uphold the existence of this compound, because, as aforesaid, a pure preparation of it is very difficult. I succeeded, however, in preparing from it, in two ways, a well characterized monobrom-dinitro-phenol, which proved to be isomeric with the above mentioned bodies.

If the monobrom-nitro-dinitro-phenol is heated with nitric acid of 1.5 spec. gr., a further nitration ensues by the splitting into two molecules of monobrom-dinitro-phenol. This can be easily separated from the raw product by water, and can be obtained from alcohol in solid yellow prisms that melt at 108° to 110°. They are not soluble in water, and are hard to dissolve in alcohol. The same body is also obtained by boiling the molecular combination for some time with baryta-water, filtering when hot, and decomposing the filtered residue with hydrochloric acid. The compound subsequently recrystallized from alcohol, showed the same melting-point (108° to 109°) and the same aspect, as also the same behavior.

(I.) 0.1976 gr. gave 27.60 per cent. C, and 1.73 per cent. H.

(II.) 0.2774 gr. gave 30.71 per cent. Br.

(Calculation for $C_6\,H_2\,Br\,(NO_2)_2\,OH$: C = 27.37 per cent. ; H = 1.14 per cent., and Br. = 30.42 per cent.)

Once I obtained, also, the same substance (melting-point 110° to 111°), by dissolving a bromphenol boiling at 238° to 240° in a *little* acetic acid, and then treating it with nitric acid of 1.5 sp. gr. in great excess ; of this product, however, I have not been able to make any analysis.

We might now have expected, that if monobrom-dinitro-phenol was separated from the above-mentioned molecular combination by hydrate of barium, monobrom-dinitro-phenol would be found in the mother-lye of the separated dinitro-product as the second product of this treatment. This, however, is not the case ; the latter (the mother-lye) contains, strange to say, a *new* and indeed more constant *molecular combination,* of the melting-point 68° to 70°. It consists of two molecules of monobrom-nitro-and one molecule of monobrom-dinitro-phenol, and has, therefore, the formula 2 $C_6 H_3 Br (NO_2) OH. C_6 H_2 Br (NO_2)_2 OH$. It can be obtained pure by precipitating the above-mentioned mother-lye with hydrochloric acid, and by crystallizing several times from alcohol the yellow, amorphous, and somewhat greasy mass, which is deposited after a few hours. This compound is, strange to say, much more stable than the one spoken of before of equal molecules of monobrom-nitro and dinitrophenol. Without changing its melting-point, it can be crystallized in various ways from hot alcohol properly diluted; it appears, accordingly, in small yellow needles united in the form of stars, which color the skin and other organic substances (paper, etc.), an intense yellow, as does also the above molecular combination.

Analysis:

I. 0.2878 gr. gave 30.51 per cent. C, and 2.20 per cent. H.

II. 0.1948 gr. gave 30.61 per cent. C, and 2.23 per cent. H.

III. 0.1941 gr. gave 33.94 per cent. Br.

(Calculation for 2 $C_6 H_3 Br (NO_2) OH. C_6 H_2 Br (NO_2)_2 OH$: C = 30.90 per cent., H = 1.57 per cent., and Br. = 34.33 per cent.)

The determination of hydrogen resulted in both cases a little too high; the cause of this is, that the copper spirals were not free from hydrogen when applied, which was noticed afterwards.

Besides these substances, I have yet to mention two nitro-compounds—one of which, it is true, I obtained only once—the second, however, repeatedly. The former gave, according to a single determination, but tolerable numbers for a *monobrom-mononitro-benzol;* but I rather believe that it represents a molecular combination. I obtained it once by treating the fourth bromphenol, after the solution in an equal volume of glacial acetic acid, with a mixture of nitric acid of equal volumes of the acid of 1.4 and 1.2 sp. gr. It melted within five degrees (between 50° and 55°). and it was manifest that it changed its melting-point by a further crystallization. The substance melting between 50° and 55° gave in the analysis the following numbers:—

0.3328 gr. substance furnished 37.27 per cent. bromine.

(Calculation for $C_6 H_3 Br (NO_2) OH$: Br = 36.70 per cent.)

In respect to the variability of its melting-point, I must, however, doubt that this product is a simple atomistic combination. I have not, therefore, endeavored to obtain it again.

The second of the above-mentioned nitro-compounds is free from bromine. It forms when, through a capillary tube, the fourth bromphenol is admitted by drops, into yellow nitric acid of 1.5 sp. gr. After the usual rectification, a substance is obtained of the constant melting-point 118°, which crystallizes from alcohol in small yellow needles that color the skin and paper deep yellow. If heated above its melting-point, it explodes violently, so that, during its analysis, the combustion-tube was broken. The analytical numbers (for C, H, and N) showed, however, that it is a very complicated compound, which contains probably 12 atoms of carbon, and does not fit any longer the benzol-derivatives. I have, therefore, desisted from further examination of it.

Finally, I must mention, that the fourth bromphenol gives, like the three known isomeres, when carefully melted with potassic hydrate, a mixture of (chiefly) resorcin, with a little pyro-catechin. The raw product indeed shows, with sesqui-chloride of iron, a green coloring; the greatest part, however, boiled in the neighborhood of 270°, and gave the well-known violet coloring (resorcin-reaction). And although the part that boiled at about 270°, after congelation and squeezing, melted between 76° and 78° (resorcin melts at 104°), and gave in the analysis proper numbers for a dioxybenzol, I cannot believe as yet, considering the boiling-point (resorcin boils at 271°) and the same behavior towards perchloride of iron, that I had an isomeric dioxybenzol in my hands.

From the foregoing data, the existence of a new (fourth) bromphenol results most clearly—a fact which is wholly incompatible with the benzol-hypothesis. It must be specially mentioned that the tendency of this derivative toward the formation of *molecular combinations according to fixed proportions* is very manifest, as is also the case with the new nitro-benzoic acids*, as well as with the fourth nitrophenol.†

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* Journal f. prakt. Chem. (2), 17, 219.

† The same (2) 24, 5.

This tendency seems, therefore, to be a property of those combinations, which, according to my hypothesis,* founded on the supposition of unequal valencies of the benzol hydrogen, are constructed unsymmetrically. Hitherto, I have not observed anything as to a direct transformation of my new bromphenol into either of those already known; it will, however, probably be effected. At all events, we have to point out, in opposition to the isomeres, the decomposition by distillation to which the fourth bromphenol is subject.

To characterize the molecular combinations, I have yet to observe, that also *a*— and *b*—dinitro—p—xylol† crystallize together, forming a combination of one and the same melting-point, and that likewise a chemical combination of butyl- and crotonyl-alcohol‡ exists, showing the same boiling-point. An investigation of such combinations, principally of aromatic bodies, will surely be of great importance in rendering our views on this subject clear.

Marburg, July, 1883.

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* Journal prakt. Chem., (2) 17, 428.

† Jahresb. d. Chem., 1881, 399.

‡ The same, 596.

III.—*Notes on the Jaw and Lingual Dentition of Pulmonate Mollusks.*

BY W. G. BINNEY.

Read March 3rd, 1884.

I propose in this paper to give, both in text and plates, a synoptical view of the jaws and lingual dentition of all the species of each genus which I have examined,—the descriptions and figures already published having lost a great deal of their usefulness by being scattered through the publications of many years of numerous scientific periodicals. I shall also have an opportunity to judge of the limits of variation, and of the amount of reliance to be placed on the characters of these organs for the purposes of classification,

In the fifth volume of the "Terrestrial Mollusks and Shells of the United States" (Bulletin Mus. Comp. Zool., IV), I have given an account of the various forms of lingual dentition, mode of extraction, etc., and descriptions of those organs in the genera found in the United States. These I will not repeat here; but, in order to understand the terms I use, I will state, that apparently the normal condition of the lingual membrane is to have three types of teeth: the central, the lateral and the marginal, named from their position on the lingual. Between the laterals and marginals there are generally several transition teeth, as the change is not sudden. The central tooth normally (that is, in the greatest number of species as yet examined) consists of a quadrate base of attachment (*a, b, c, d,* of pl. VII, fig. 1), with expanded lower outer angles, and the whole upper surface reflected. The reflection (*e*) is tricuspid (one median, *f,* and two side ones, *g, h*), and each cusp is continued into a cutting point (*i, j, k*). This last I have shaded in my figures, for the purpose of distinction, but no shading exists in nature. The lateral teeth differ from the central by the suppression of the inner lower angle of the base of attachment and the inner cusp and cutting point of the tooth. Thus they are asymmetrical. As they pass outward, they become modified into marginals by the comparative enlargement of the reflection and diminution of the base of attachment, and by the splitting of each cutting point, as well as by the much diminished size of the whole tooth. This form of dentition is, as seen in my description, characterized by *quadrate marginal teeth*, from which the other large division is distinguished by having marginal teeth of a strictly *aculeate form* (see pl. II, fig. H, three left-hand teeth). For the purposes of classification, this distinction of quadrate and aculeate marginal teeth is most important. It sometimes occurs that the central (see fig. K, of pl. XVII) is missing, or the laterals are missing (fig. H, pl. XVII). When the dentition does not agree with either of these two forms, I have considered it abnormal, and described its characters, unless the genus is found in the United States, when I simply refer to my descriptions in Terr. Moll. U. S., V. It must be remembered, however, that there is some variation found from the tooth referred to on pl. VII; the side cusps and cutting points, especially, being in some genera obsolete (see all the figures on plate IX.)

A complete list of the lingual membranes examined by me is given in Bull. M. C. Z., Vol. V, No. 16, pp. 339—350. With the original description will be found the name of the person furnishing the membrane. Those from the West Indies were identified by Mr. Thomas Bland. The mounted lingual membranes will be found in the Museum of Comparative Zöology at Cambridge.

W. G. Binney,

Burlington, New Jersey.

AGNATHA.

Chlamydephorus.

Chlamydephorus Gibbonsi, W. G. Binney. Natal Colony, Africa, Mr. J. S. Gibbons.

The lingual membrane is long and broad, consisting of about 52 chevron-shaped rows of 27–1–27 teeth, all as in *Glandina*, the central one differing only in being smaller than the adjacent marginals, and symmetrical, with a long, slender cutting point; there are no laterals, all the side teeth being purely aculeate marginals, and first rapidly increasing and then gradually decreasing in size as they pass off laterally, as is usual in *Glandina*. Buccal mass very large indeed. (Pl. XVII, fig. A.)

The plate shows the central and three adjacent marginal teeth, the eighth marginal, aud the twenty-third to the twenty-seventh, which is the last.

Glandina.

For the description of the dentition of the genus, see Terr. Moll. U. S., V. All the species examined by me agree with it. There are no lateral teeth.

Glandina semitarum, Rang. (*Varicella*), Martinique. Gov. Rawson.

There are about 30–1–30 teeth. The central is long, narrow, and sharply pointed. (Plate XVII, fig. C.)

Glandina Phillipsi, Ad. (*Varicella.*) Jamaica.

As in the last species; Pl. XVII, fig. D, shows an outer marginal. There is a peculiar notch in the upper edge of the base of attachment.

Glandina rosea, Fér. Nicaragua. Mr. McNiel.

Membrane with 36 rows of 25–1–25 teeth. Centrals long, narrow, slightly incurved at sides, emarginate at top, rounded at base, and bearing a short, blunt, stout, cutting point. (Pl. XVII, fig, B.)

Glandina aurata, Mor. Costa Rica, Dr. W. M. Gabb.

Referred to as an undetermined species in Ann. N. Y. Ac. Sci. I, 261.

Teeth, 36–1–36. The central tooth has a long slender cutting point. (Pl. XVII, fig. E.) The central tooth and first four marginals.

Glandina solidula, Pfr. (*Oleacina.*) New Providence.

Lingual membrane as usual in the genus.

Glandina Albersi, Pfr. Lower California.

In L. and Fr. W. Sh. of N. A., I, 19, is a figure of the dentition of this species, drawn by Mr. E. S. Morse. There are 32–1–32 teeth.

Gonospira.

Mauritius. Consul Pike.

There are no laterals. The central tooth has a short, blunt, rounded cutting-point. The marginals increase at first very rapidly in size.

G. palanga, Fér. Teeth, 37-1-37. (Pl. XVII, fig. F.) A photograph of this membrane will be found in Am. Journ. Conch., V, 37.

G. Newtoni, H. Ad. Teeth, 6-1-6. (Pl. XVII, fig. G.)

G. Mauritiana, Morel. Teeth, 12-1-12. (Pl. XVII, fig. H.)

G. modiolus, Fér. Teeth, 25 1-25.

G. Nevillei, H. Ad. Teeth, 21-1-21. (Pl. XVII, fig. I.)

G. sulcata, Müll. Lingual membrane as in the other species examined.

Ennea.

Ennea clavatula, Lam. Mauritius. Pl. XVII, fig. J. Consul Pike.

Lingual membrane as in *Gonospira.*

Spiraxis.

Spiraxis Dunkeri, Pfr. San Domingo. Mr. J. S. Gibbons.

The membrane (pl. XVII, fig. K) has no central or lateral teeth. Those present are all marginals, of the form common in *Glandina*, and arranged *en chevron*. The figure gives three on each side of the centre of the membrane.

Rhytida.

Rhytida vernicosa, Krauss. Cape Town, South Africa.

This genus also, has no central or lateral teeth. The marginals are arranged as in *Glandina*. Pl. XVII, fig. L, gives the whole of one half of one transverse row of teeth. The formula is 14–0–14. The rows of teeth are close together, not separated.

The species cannot be retained in *Pella*, a sub-genus of *Helix*, where Von Martens placed it.

Onchidium.

Onchidium Schrammi, Bl. and Binn. Pointe à Pitre, Guadeloupe. Mr. A. Schramm.

Pl. III, Fig. A. Both the teeth on each transverse row, and the rows themselves, are greatly crowded. The general arrangement of the lingual membrane is the same as I have described for that of *Onchidella* in Terr. Moll., V.

Onchidium is allied to the preceding genera merely by the absence of a jaw.

HOLOGNATHA VITRINEA.

This section includes genera furnished with a jaw in one single piece, and marginal teeth of the lingual membrane *aculeate.*

Stenopus.

Stenopus decoloratus. Demerara. Mr. J. S. Gibbons.

Jaw low, wide, slightly arcuate: ends blunt and but little attenuated; cutting-edge without median projection.

Lingual membrane (pl. XVII, fig. M) long; teeth 23–1–23, arranged *en-chevron;* centrals small; upper margin elongated, tricuspid; no lateral teeth; all the side teeth are aculeate marginals; those nearest the median line somewhat modified in shape.

Not having examined a living specimen, I am not able to say whether the species has the caudal appendage characteristic of *Stenopus.*

Limax.

For description of jaw and lingual membrane, see Terr. Moll. U. S., V.

Limax semitectus, Mörch. Costa Rica. Dr. W. M. Gabb.

Jaw (pl. XV, fig. I) smooth, arched, ends attenuated; a median projection to the cutting-edge; a reinforced space on the centre of the jaw.

The lingual membrane (pl. II, fig. G) is long and narrow. There are 44–1–44 teeth. The centrals have side cusps and cutting-points. The laterals, twelve in number, on each side of the central, are bicuspid; the marginals are aculeate,—all of them are bifid by having the side spur often found on the side marginals in this genus. The 13th, 14th and 15th teeth form the transition into the marginals.

The figure gives the central, the first lateral on one side of the median line, and two marginals, the sixteenth and forty-fourth teeth.

Urocyclus.

Urocyclus Kirkii, Gray. Mozambique. Mr. J. S. Gibbons.

Jaw (pl. XVI, fig. K) very low, slightly arcuate; ends scarcely attenuated, blunt; anterior surface without ribs; no median projection to the cutting-edge; a strong muscular attachment.

Lingual membrane (pl. XVII, fig. N) with tricuspid centrals, bicuspid laterals, as in *Zonites*, and aculeate marginals, all of which are bifid.

The figure shows one central, one lateral, and two marginals.

Nanina.

The species of this genus have tricuspid centrals, bicuspid laterals, and bifid aculeate marginals. I have examined from Mauritius (Consul Pike),—

Nanina Caldwelli, Benson.

N. Rawsonis, Barclay. (Pl. II, fig. D.)

N. argentea, Rve. (Pl. II, fig. C.)

N. implicata, Nev. (Pl. II, fig. B.)

N. stylodon, Pfr.

The last cannot be retained in *Erepta*, a sub-genus of *Helix*, where it was placed by Von Martens. All the above have similar dentition. Also from Mauritius—

N. philyrina, Morelet.

Though this species agrees in other respects with the above-named, the membrane is very broad, the teeth exceedingly numerous, arranged in oblique rows. The centrals, which I am confident of having seen, are small, narrow, high. The other teeth are the same in form to the edge of the membrane. They appear to have the usual aculeate form of the marginal teeth in *Nanina;* but instead of narrowing towards the cutting-point, they are broadly and obliquely truncated, reflected, and minutely denticulated. This lingual membrane is also figured by Semper (Phil. Archip., pl. VI, f. 35); but his figures give more the impression of the usual *Nanina* marginals with denticulated side and bifid points. The teeth are, however, so exceedingly numerous and small that it is very difficult to understand them.

Nanina inversicolor, Fér.

Also from Mauritius, has the character of animal, jaw, and lingual membrane of *Nanina*, so that it cannot be retained in *Caracolus*, a sub-genus of *Helix*.

Nanina militaris,

Of same locality, for the same reasons cannot be retained in *Stylodon*, and—

Nanina leucostyla, Pfr.

Nanina rufozonata, H. Ad.

From Mauritius, prove also to belong to *Nanina.*

Nanina radians, Pfr. (*Microcystis*). Rarotonga Island. Mr. A. Garrett.

Plate XVII, fig. P, represents one central, lateral and marginal tooth. There are 40–1–40 teeth, eight on each side being perfectly formed laterals. The marginals are sometimes trifid.

Nanina conula, Pease. Island of Huahine. Mr. A. Garrett.

Central and lateral teeth as in *N. radians*, Pfr. (See above.) Lateral teeth, seven in number on each side. Marginals aculeate, multifid, very numerous.

Nanina calculosa, Gould. Island of Huahine. Mr. A. Garrett.

Jaw as usual in the genus. Lingual membrane long and narrow. Teeth, 38–1–38. Centrals and (7) laterals as in *N. radians*. (See above.) The latter, however, have slightly developed inner side cutting points. First 15 marginals bifid, the rest multifid.

Nanina Cressida, Gould. Island of Huahine. Mr. A. Garrett.

Jaw arched, high; ends blunt; cutting-margin with a median beak-like projection.

Lingual membrane (Pl. XVII, fig. Q) with 55–1–55 teeth. The bifurcation of the cutting-point of the marginals commences in the 11th tooth. There are no side cusps to the centrals and laterals, which have a long, narrow base of attachment on each side. I figure one central, one lateral and one marginal tooth.

Nanina Chamoissi, Pfr. West Maui, Sandwich Islands. Gulick.

Pl. XVII, fig. O. The marginal teeth have three or four points. An unidentified species from Oahu has similar dentition.

Nanina subcircula, Mousson. Raiatea, Society Islands. Mr. Garrett.

Lingual membrane (Pl. II, fig. A) as in the other species.

Nanina cultrata, Gould.

Lingual membrane as usual in the genus. Laterals six on both sides; extreme marginals multifid.

Nanina Calias, Benson. Foot of Himalayas. Mus. Comp. Zöol.

Lingual membrane with ten laterals on each side, still more bifid marginals. (Pl. II, fig. E.) On the same plate, fig. F, is figured a central tooth from another part of the same membrane, in which the cutting point is abnormally developed.

Velifera.

Known only by the single species, *V. Gabbi*, Costa Rica. Dr. W. M. Gabb.

Jaw with smooth anterior surface and beak-like projection to the cutting edge.

Lingual membrane (Pl. II, fig. H) with the general arrangement of *Zonites;* the first laterals have an inner side cutting point; marginals aculeate, with side spur.

Its lingual membrane resembles that of *Limax agrestis*, in having the inner, abnormal side cutting point to its first lateral teeth. All the marginals are bifid.

Macrocyclis.

Macrocyclis Baudoni, Petit. Guadeloupe, Mr. Schramm; Dominica, Mr. Guppy.

Jaw delicate, transparent, colorless; ends pointed; anterior surface smooth; cutting edge with median projection.

Lingual membrane as in *Macrocyclis*. (See Terr. Moll., V.) I could not distinguish the characters of the very small central tooth.

Macrocyclis euspira, Pfr. Placed in *Ammonoceras*, a subgenus of *Hyalina*, by von Martens, but, from its lingual membrane, shown to belong to *Macrocyclis*.

Jaw low, crescentic; ends pointed; cutting margin with a decided, sharp, median projection.

Lingual membrane (pl. II, fig. I) long and narrow; teeth arranged as in *Macrocyclis*. There are, however, no transition teeth, as in the American species; all the side teeth being true marginals of the aculeate type. Teeth, 30–1–30. The centrals are deeply emarginate at the upper edge of their base of attachment, and have expanded lower lateral angles; they have also a well-marked, simple, median cusp, with a decided cutting point.

Zonites. (See Terr. Moll., V.)

Zonites? Bermudensis. Pfr. Bermuda. Mr. J. J. Crooke; Mr. J. Matthew Jones.

Jaw extremely thin, arched, with a blunt, median projection to its cutting edge.

Lingual membrane long and narrow. Central teeth tricuspid; laterals bicuspid; the cusps in each long and slender. Marginals numerous, aculeate, in oblique rows.

The result of my examination of the lingual membrane throws light on the generic position of this species. It can no longer be retained in *Caracolus*, a sub-genus of *Helix*, as proposed by von Martens, since it has the dentition of the *Vitrinea* of von Martens' arrangement. It differs, however, from *Zonites*, in having no longitudinal furrows above the margin of the foot, and no caudal mucus-pore. It seems to belong to no described genus.

Janulus.

Janulus stephanophora, Desh. Madeira. Dr. Hillebrand.

Jaw strongly arched; ends pointed; cutting margin with a sharp, greatly produced median projection.

Janulus bifrons, Lowe. Madeira. Dr. Hillebrand.

Jaw smooth, with median projection.

Lingual membrane with 34–1–34 teeth, of which four on each side are laterals, all as in *Zonites*.

HOLOGNATHA HELICEA.

This section contains the genera furnished with a jaw in one single piece, and quadrate marginal teeth to the lingual membrane.

A. Jaw ribless.

I still retain this section, though several species in various genera have ribs on their jaw.

Tebennophorus. (See Terr. Moll., V.)

Tebennophorus Costaricensis, Mörch. Costa Rica. Dr. W. M. Gabb.

Jaw strongly arched, of equal width to its blunt extremities. There are sub-obsolete anterior ribs about the centre of the jaw, the ends of five of which denticulate the cutting margin.

The lingual dentition is figured on Plate VIII, fig. N. There are about 28–1–28 teeth. The centrals have a long base of attachment, with a strong line of reinforcement running parallel to its margin at the lower edge and for a short distance at the sides. The reflection is small, and bears a short, stout median cusp, and small stout side cusps; all three cusps bearing short, stout cutting points. The lateral teeth are like the centrals, but asymmetrical by the suppression of the inner cusp and cutting point and the inner lower expansion of the base of attachment. The marginals are but a modification of the laterals; the inner cutting point not becoming bifid, though the outer one is so on the extreme marginals. There are hardly more than twelve perfect laterals on each side. The change into marginals is very gradual.

Sagda.

Sagda connectens, Ad. Jamaica. Mr. Jas. Milligen.

Lingual membrane with 26–1–26 teeth. The centrals have their plates short in comparison to the reflection, and broad. The middle cusp is long, with a long slender point. The side cusps are sub-obsolete, with short, acute, triangular points. The laterals are of the same type as centrals, but bicuspid, the outer cusp more developed than the external cusps of the centrals. The marginals are wide, low, with one long, oblique, blunt, narrow inner cusp, and one or more side small cusps.

The genus is included in the *Vitrinea* of von Martens; but I have shown that it belongs to the *Helicea*, the marginal teeth being quadrate, not aculeate.

Sagda Haldemaniana, Jay. Jamaica. Messrs. Gloyne and Vendreyes.

Jaw slightly arcuate, of almost equal height throughout; ends blunt; no anterior ribs; no median projection to the cutting edge.

Lingual membrane with about 30-1-30 teeth, as in the last species. (Pl. II, fig. K.)

Sagda Jayana, Ad. Jamaica. Mr. Henry Vendreyes.

Jaw smooth; scarcely any median projection to cutting edge.

Lingual membrane with teeth characterized as in last species.

Endodonta.

I regret not succeeding in obtaining the jaw of any species of this genus, the more because some doubt of its existence has been expressed. It is, however, probable that it will be found, as no agnathous genus has yet been noticed with the quadrate marginal teeth which characterize *E. incerta*, and also *E. tumuloides*, Garrett.

Endodonta incerta, Mousson. Huahine Island. Mr. A. Garrett.

Lingual membrane (Pl. II, fig, N) with 11-1-11 teeth, of which four on each side are perfect laterals. The marginals (of which the last is shown in the figure) are but a simple modification of the laterals. They differ from those of *tumuloides* in not having a bifid inner cutting point, unless indeed I have, from their exceeding minuteness, failed rightly to interpret them.

Endodonta tumuloides, Garrett. Rarotonga Island, Cook's Island. Mr. Garrett.

Lingual membrane (Pl. II, fig. M) with 17-1-17 teeth, with about seven perfect laterals on each side. Teeth as in last species; but the inner cutting point of the marginals is bifid.

Patula.

Patula Huahinensis, Pfr. Huahine Island. Mr. A. Garrett.

Jaw not examined.

Lingual membrane with 18-1-18 teeth, of which about six on each side are laterals. The type of dentition is about the same as in *Endodonta incerta*, described above. The marginals are, however, different, the two cutting points being bifid, the base of attachment low and wide. (Plate II, fig. L.)

Pella.

The character of the jaw does not allow the genus to hold a position here, among "ribless jaws."

Pella rariplicata, Benson. Cape Town, S. Africa. Mr. J. S. Gibbons.

The jaw has flat, crowded, numerous ribs, such as I have described for *Microphysa Lansingi*, in Terr. Moll., V.

Lingual membrane (Pl. III, fig. I) long and narrow. About 16-1-16 teeth, with four laterals on each side of the central tooth. The central tooth has small side cusps and cutting points. Laterals like the centrals, but slightly asymmetrical by the lesser development of the inner side; an unusual arrangement in the *Helicidæ*. The marginals are low, wide, with one inner, wide, bifid cutting point, and one smaller, bifid outer cutting point, giving a serrated appearance to the cutting edge.

A central tooth, with its adjacent laterals, and two marginal teeth, are given in the figure.

Polymita.

Having found two different forms of dentition in the species referred by Von Martens to *Polymita*, I propose to restrict this genus to those species which have the abnormal dentition of its type, *P. muscarum*, leaving those with the usual dentition of the *Helicidæ* under the name of *Hemitrochus*.

The peculiar dentition of *Polymita*, entirely unexpected from the appearance of the shell, is one of the most interesting facts I have met with. It is not only different from that of its allied forms, but also from that of all species of the Pfeifferian genus *Helix* as yet examined.

The peculiar dentition is shared by *picta*, Born, and may be looked for in *sulphurosa*, Morelet. These two species are placed by von Martens, in *Liochila*, together with *Helix Jamaicensis*. The two former I put with *muscarum* in *Polymita*. For the last, see below.

Polymita muscarum, Lea.

Jaw wide, low, arched, delicately striated; ends attenuated, bluntly rounded; no anterior ribs; no median projection to the cutting edge. (Pl. XV, fig. K.)

Lingual membrane long and narrow, composed of numerous rows of about 75-1-75 teeth each. The transverse rows are arranged *en chevron.* Centrals with base of attachment long, narrow, incurving at the sides; upper margin slightly rounded; lower margin trilobed and fringed; on the lower fourth of the base of attachment springs a trilobed, gouge-shaped, cutting edge, broader than the base, and bearing three cusps, each produced into a cutting point, the central triangular, the external ones curving outwards, neither produced beyond the lower margin of the base of attachment. The side teeth (which do not resemble the usual form either of laterals or marginals) are of the same form as the centrals, but rendered asymmetrical by the lesser development of the inner lower angle of the base of attachment, and by its being thrown abruptly off towards the margin of the membrane; the lower edge is also rounded, and not trilobed as in the centrals; the laterals, also, are longer, narrower, with a less expanded upper margin of the base of attachment than in the centrals, in a contrary direction from which they are also thrown off by the irregular curving of the base of attachment. The cusps and cutting points of the side teeth are like those of the centrals.

In one lingual membrane examined, I noticed two abnormal rows of teeth down the whole length of the membrane, in which the cutting edge was divided into four lobes, instead of three, all bearing cutting points. These abnormal lines of teeth were separated by a normal line.

The figure (Pl. III, fig. C) shows a group of central and side teeth, while a single central, still more enlarged, is shown in D.

These peculiar, long, subquadrangular bases of attachment, not reflected along the upper margin, as usual in the *Helicidæ*, but bearing the gouge-shaped, expanded cutting edge, soldered as it were upon its surface, can only be compared to those of *Gæotis*, and those of the marginal teeth of *Orthalicus* and *Liguus*.

Polymita picta, Born. Cuba. The specimen examined was found on a bunch of bananas in New York.

Jaw as in *muscarum*.

Lingual membrane (Pl. III, fig. E) with the same characteristics as that of *muscarum;* but the teeth are shorter and stouter. (Plate III, fig. E.)

HEMITROCHUS.

I have examined only five species of those remaining in von Martens' *Polymita,* after removing its type, *muscarum,* as explained above. *Helix versicolor,* Born, is the only remaining species in which the dentition of *muscarum* and *picta* may be looked for. The others will probably agree with *varians*, etc.

The jaw of *varians*, *gallopavonis*, *Troscheli*, *rufoapicata*, *graminicola*, is high, arched, without ribs, with a blunt median projection. In one species, *Milleri*, the jaw is like this, excepting that it has one decided, stout, central rib, denticulating either margin. This shows that the presence or absence of ribs on the jaw cannot be considered a reliable generic character. (See, also, *Dentellaria*.)

Hemitrochus varians, Mke. (See Terr. Moll., V.)

Hemitrochus Troscheli, Pfr. New Providence, Bahamas. Gov. Rawson.

Jaw as described; a strong, transverse line of re-enforcement.

Lingual membrane (Pl. IV, fig. A) long and narrow. Central teeth very long; the upper margin of base of attachment greatly produced above; the reflected portion not extending to the lower margin; median cusp with a short, blunt cutting point; side cusps and cutting points obsolete. Laterals like the centrals, but asymmetrical; the upper margin still more produced; outer laterals with bifid inner cutting point, and side cusp and cutting point. Marginals quadrate, with one large, oblique, rounded, bluntly bifid cutting point, and one or two side, small, blunt cutting points. The membrane is peculiar in the extension of the upper margin of the base of attachment of the teeth.

Hemitrochus gallopavonis, Val. Turk's Island. Gov. Rawson.

Jaw as described.

Lingual membrane as described in last species. (Pl. IV, fig. B.)

Hemitrochus rufoapicata, Poey. Cuba. Mr. Arango.

Jaw and lingual membrane (Pl. IV, fig. C) as described above.

Hemitrochus graminicola, Ad. Jamaica. Messrs. Vendreyes and Gloyne.

Jaw as described.

Lingual membrane (Pl. IV, fig. E) as described. Teeth 40-1-40.

Of the above species, the figure gives one central, the adjacent lateral or laterals, and one or more marginals.

Hemitrochus Milleri, Pfr. Fortune Island, Bahamas. Dr. J. J. Brown.

Jaw differing from that of the above species by the presence of a stout, median rib-like prominence, denticulating either margin. (Pl. XVI, fig. J.) See above, under generic name.

Lingual membrane with 33-1-33 teeth, characterized as in the other species. Fig. D, of pl. IV, shows one central and adjacent lateral, an outer lateral (7th tooth) showing the side cusp and cutting point; the eighth lateral, in which the inner cutting point first is bifid, the sixteenth tooth, still a lateral, though somewhat modified in form, and a marginal, the last tooth. It will be noticed that, on the central and first lateral, the cutting point has a side bulging, probably a modification of the missing side cutting point. No doubt this bulging exists in the other species of the genus, though not shown in the focus under which my figures were drawn.

Acavus.

Acavus Phœnix, Pfr.

Jaw wide, low, arcuate ; ends but slightly attenuated, blunt, very thick and coarse; no anterior ribs; no median prominence to the cutting edge.

Lingual membrane (Pl. II, fig. O) with long and narrow centrals and laterals; the upper margin of the base of attachment produced and rounded; the reflection is stout, as are the cusp and cutting point, of which only the middle one exists. Marginal teeth simply a modification of the laterals.

Caracolus.

In this genus, also, there is a difference as regards the presence or absence of ribs on the jaw.

Lingual membrane characterized by the absence of side cusps and cutting points.

Caracolus Bermudensis, of von Martens' list, I have above shown to be more nearly allied to *Zonites* than to any known genus. *Caracolus inversicolor* I have above referred to *Nanina.*

Caracolus excellens, Pfr. San Domingo. Dr. Newcomb.

Jaw not examined.

Lingual membrane (Pl. IV, fig. F).

Caracolus sagemon, Beck. Cuba. Mr. Arango.

Jaw high, arcuate; ends rapidly but slightly attenuated, blunt; cutting margin with broad, blunt, median projection; no anterior ribs.

Lingual membrane (Pl. IV, fig. G) very long and narrow, with 36-1-36 teeth; the transverse rows of teeth being unusually oblique, though not so represented in my figure. The change from laterals to marginals is very gradual, so that it is difficult to count the former. Centrals with base of attachment long, constricted at the middle, expanded above, and with greatly produced lower lateral angles; reflection large, with obsolete side cusps and no side cutting points, and with a very broad, short median cusp, bearing a short, widely-expanded, square edge (as it cannot be called a *point*). Laterals like the centrals, but asymmetrical, as usual, and with an asymmetrical cutting edge larger than in the central tooth. The cutting edge becomes more developed as the teeth pass off laterally, in proportion to the base of attachment and the cusp also. Thus the marginals become formed without any splitting of the inner cutting point, or any development of a side cusp and cutting point, excepting that on some of the teeth a blunt obsolete side cusp may be shown.

The form of this species from Gonave Island, Haiti, (Prof. Linden,) is said by Mr. Bland to have a white, instead of a reddish-brown, peristome. The lingual membrane is figured on Pl. IV, fig. H. The cutting points on all the teeth are more produced than in the Cuban *sagemon* and *Arangiana;* after the eighth tooth there is a decided side cutting point on the laterals and marginals. The jaw is the same as in *sagemon.*

Caracolus Arangiana, Poey. Cuba. Mr. Arango.

Jaw (Pl. XV. fig. M) greatly arched ; ends blunt, scarcely attenuated ; cutting margin with a blunt, median projection.

Lingual membrane (Pl. IV, fig. I) with 33-1-33 teeth, arranged as in *sagemon*. The lower margin of the base of attachment seems delicately fringed.

Caracolus marginella, Gmelin. Porto Rico. Mr. R. Swift.

The jaw differs from that of the other species examined, in having stout anterior ribs.

Lingual membrane (Pl. IV, fig. J).

Leucochroa.

The genus *Leucochroa* is adopted by von Martens, the type being *Helix candidissima*, Drap., a species whose anatomy has been described by Moquin-Tandon as being more nearly related to *Zonites* than to *Helix*. The genus is classed by von Martens among the *Vitrinea*, the section of *Helicea* containing the genera furnished with ribless anterior surface and median projection to the jaw, and aculeate, marginal teeth to the lingual membrane. Among the species catalogued by von Martens is *Leucochroa Boissieri*, Charp. We find, however, that both jaw and lingual membrane in this species indicate that the genus belongs to the *Helicea*.

Leucochroa Boissieri, Charp. Palestine. Mr. John Van Nostrand.

Jaw very low, long, arcuate; ends but little attenuated, bluntly rounded; cutting edge with a decided median projection; anterior surface free from ribs, with a strong transverse line of reinforcement. The jaw resembles that of *Clausilia* or *Pupa* more than that usually found in *Helix.*

Lingual membrane as usual in the *Helicidæ.* Centrals short and stout, with a blunt cutting point to the central tooth; the cusps obsolete. Laterals with a very long, oblique, blunt inner cutting point; the outer cutting point obsolete. Marginals subquadrate, with several short, blunt, cutting points. (Pl. II, fig. J.)

Ochthephila.

In this genus, again, the presence or absence of ribs on the jaw is not a reliable character.

Ochthephila tiarella, Webb and Broll. Madeira. Dr. Hillebrand.

Jaw low, slightly arcuate; ends scarcely attenuated; anterior surface with about 15 flat, broad, crowded ribs, scarcely denticulating the cutting margin.

Lingual membrane with 21-1-21 teeth, of same character as figured in *Plebecula lurida.* About nine laterals on each side of the median line.

Ochthephila abjecta, Low. Madeira. Dr. Hillebrand.

Jaw low, slightly arcuate; ends attenuated; cutting edge with a blunt median projection; no anterior ribs.

Lingual membrane with 24-1-24 teeth, about four on each side being perfect laterals, characterized as in the last species.

Cysticopsis.

The jaw described under *C. tumida* is peculiar. There is considerable difference in the dentition of the two species examined.

Cysticopsis tumida, Pfr.

Jaw (Pl. XVI, fig. A) wide, low, slightly arcuate, scarcely attenuated at the blunt ends; a slight, broad, median projection to the cutting edge; with delicate, separated, longitudinal striæ, passing into a long, narrowing, conical prolongation of the jaw, springing from about the centre of its surface, and distinct from the muscular attachment of the jaw.

Lingual membrane (Pl. V, fig. A) with 22-1-22 teeth. Centrals very broad, with a small reflection bearing three distinct cusps and cutting points. Laterals like the centrals, but bicuspid and asymmetrical. Marginals low, wide, with one inner, larger, cutting point, and one outer, smaller, bifid cutting point.

Cysticopsis pemphigodes, Pfr. Cuba.

Jaw not examined,

Lingual membrane (Pl. V, fig. B) long and broad. Teeth as in *Plagioptycha,* not as in *Cysticopsis tumida.*

Plagioptycha.

Jaw arcuate, ends slightly acuminated, blunt; no anterior ribs: a decided median projection to the cutting edge:—*P. loxodon*, Pfr., *Albersiana*, Pfr., *monodonta*, Pfr., *diaphana*, Lam., *macroglossa*, Pfr. In *P. Duclosiana*, Fér., however, there is a decided median, stout rib, denticulating either margin. Thus the presence or absence of ribs on the jaw cannot be considered a generic character in *Plagioptycha*.

The character of the lingual dentition in the species examined agrees.

Plagioptycha loxodon, Fér. San Domingo. Dr. W. Newcomb.

Lingual membrane (Pl. V, fig. C) long and narrow. Centrals having a long, narrow base of attachment, with expanded lower angles and lines of reinforcement within them; reflected portion small, with a single stout cusp and cutting point; laterals like centrals, but asymmetrical; outer laterals with outer cusp and cutting point; the inner cutting point becomes bifid as the teeth pass into marginals, which become low and wide, with two broad, bluntly rounded, usually bluntly bifid cutting points.

Plagioptycha Albersiana, Pfr.

Jaw as above.

Lingual membrane like last. (Pl. V, fig. D.)

Plagioptycha monodonta, Pfr. San Domingo. Dr. Newcomb.

Jaw as above.

Lingual membrane (Pl. V, fig. E) like that of *P. loxodon*.

Plagioptycha Duclosiana, Fér. Exuma, Bahamas. Dr. J. J. Brown.

Jaw as described above.

Lingual membrane (Pl. V, fig. F) with about 30-1-30 teeth. The figure shows the gradual changes in the teeth, the seventh being the last lateral. The side bulgings in the cutting points of central and first laterals are shown by using a different focus in the microscope than that used in drawing the figures of the other species. It represents the side cutting point.

Plagioptycha diaphana, Lam. Porto Rico. Dr. Cleve.

Jaw as above.

Lingual membrane (Pl. V, fig. G) as in *loxodon*.

Plagioptycha macroglossa, Pfr.

Jaw as above.

Lingual dentition (Pl. V, fig. H) as in *loxodon*.

Leptoloma.

Only one species examined :—

Leptoloma fuscocincta, Ad. Jamaica.

Jaw thin, arcuate, high, ends bluntly truncated; with perpendicular striæ; cutting edge with a median projection.

Lingual membrane (Pl. V, fig. I) as in *Plagioptycha*.

Achatinella.

In Annals of Lyceum of Nat. Hist. of New York, X, 331; XI, 190, are given in detail my observations on the anatomy of *Achatinella*. I here give a summary only of what relates to the jaw and lingual dentition.

Most of the specimens examined were sent by Mr. Gulick. A few were received from the Museum of Comparative Zöology.

I have here grouped the species according to von Martens' arrangement and sub-genera. I will state that, of Mr. Gulick's arrangement, the species examined represent the sub-genera—*Achatinella, Bulimella, Apex, Partulina, Auriculella, Laminella, Amastra, Leptachatina,*—all except *Newcombia: Carelia* is treated below.

The result of my examination may be briefly stated, viz.: that I find two types of dentition, one (*a*) including the species of *Partulina* and *Achatinella*, s. s. ; the second (*b*) comprising all the species examined, of *Newcombia, Laminella, Leptachatina.*

Bulimella, Apex and *Labiella*, of von Martens' arrangement, were not examined. Of these we may expect to find the first two agreeing with my first section (*a*) in dentition; the last, with my second (*b*).

In the section (*a*) suggested by me, the species are all characterized by a jaw so extremely delicate as to be found with great difficulty. It cannot be extracted by potash. It is arcuate, extremely thin, transparent, with blunt ends. The lingual membrane agrees with that figured by Heynemann of *A. bulimoides.* It is very broad in comparison to its length. In one lingual there were 175-1-175 teeth. They are arranged *en chevron.* There is but one form of tooth for centrals and side teeth (it is difficult to call the latter laterals or marginals), but the centrals are somewhat smaller and symmetrical. The base of attachment is long and narrow, squarely truncated below, rapidly widening and curving outwards at its upper third, so that the upper margin is twice the breadth of the lower; it is rounded and reflected along its whole breadth; reflection small, bearing five or more cusps and cutting points, the median the smallest. There is some variation in these cusps. Of this type of jaw and dentition are:—

Partulina jucunda, Smith. W. Maui.
plumbea, Gulick. E. Maui.
eburnea, Gulick. E. Maui.
solidissima, Smith. E. Maui.
solida, Gulick. Oahu.
tæniolata, Pfr. Oahu.
marmorata, Gld. Oahu.
pallida, Nutt. Oahu.

Achatinella (s. s.) *producta*, Rve. Oahu. (Pl. III, fig. G.)
Johnsonii, Newc. Oahu.
livida, Swains. Oahu.
varia, Gulick. Oahu.
auricula, Fér.

In the last three species, I failed to extract the delicate jaw. *Achatinella auricula*, Fér., on account of its having this type of dentition, I remove from *Partula*, where it is placed by von Martens.

The peculiar type of dentition shared by the above species is seen on my Pl. III, fig. G. (*A. producta*, Rve.)

(*b*) Of the second type of jaw and dentition are the remainder of the species examined. The jaw is stout, arcuate, ends blunt, no anterior ribs; generally a median projection to cutting edge. In *Laminella Mastersi* it is low, wide, slightly arcuate, horn-colored; no median projection. (Pl. XVI, fig. E.) It is the same in the other species of *Laminella*. The same type of jaw, though more arched, is found in all the species of *Newcombia* and *Leptachatina*. In *picta* (Pl. XVI, fig. M) there is a slightly produced, blunt, median projection to the cutting edge. There are often delicate vertical striæ on this type of jaw.

The lingual dentition in this section is entirely different from that in the last. The membrane is long and narrow. The transverse rows of teeth are horizontal, not *en chevron*. The teeth are like those usually found in the *Pulmonata*, with quadrate base of attachment and tricuspid centrals, bicuspid laterals, bicuspid, multicuspid, or even pectinate marginals. The centrals are very much smaller than the laterals, both in height and width.

Newcombia picta, Mighels. W. Maui.

Jaw described above. Lingual membrane, Pl. VI, fig. B. The marginals have two cutting points, each point becoming bifid as the teeth pass off laterally.

Newcombia venusta, Mighels.

Jaw slightly arcuate, with blunt ends; a few vertical wrinkles.

Lingual membrane (Pl. VI, fig. A) shown in all its changes. The marginals are decidedly pectinate in the teeth figured, but some are seen with only two cutting points. Teeth 24-1-24, eight being laterals on each side of the median line.

Laminella Mastersi, Newc. West and East Maui.

Jaw described above. (Pl. XVI, fig. E.)

Lingual membrane (Pl. VI, fig. E) with simply two or three cutting points to the marginals. A group of these latter, and of centrals and laterals, is given.

Laminella obesa, Newc.

Lingual membrane (Pl. VI, fig. C) with 27-1-27 teeth, of same type as in the last species.

The tooth shown in the figure is the 19th, a marginal, with one large, inner cutting point, and three very small outer ones. On the same membrane, however, are some marginals having three cutting points and some which are quite pectinate. This variation shows that my distinction between *b* and *c*, in my former paper, referred to above, was not well founded,

The jaw is as in *A. Mastersi.*

Laminella decorticata, Gulick. Oahu.

Lingual membrane (Pl. VI, fig. D) as in *Mastersi.*

Laminella luctuosa, Pfr. Oahu.

Lingual membrane (Pl. VI, fig. F) as in *Mastersi.*

Laminella nigrolabris, Smith. Oahu.

Lingual membrane as in *Mastersi.*

Leptachatina nitida, Newc. W. Maui.

Lingual membrane (Pl. VI, fig. H), marginals pectinate.

Leptachatina grana, Newc. W. Maui.

Dentition as in last species.

Leptachatina dimidiata, Pfr. Oahu.

Same dentition.

Leptachatina textilis, Fér.

The dentition is as in the other species of the subgenus examined by me. There are 26-1-26 teeth, with eight laterals on each side. On Pl. VI, fig. G, I figure the whole change from central to extreme marginal teeth. The last are not pectinate.

Tornatellina.

Considered by von Martens as a sub-genus of *Cionella*, but by its dentition closely related to *Achatinella*, *s. s.* The jaw was not examined.

Tornatellina aperta, Pease. Huahine Island. Mr. A. Garrett.

Lingual membrane (Pl. III, fig. F). The figure represents the central, with the first and second side teeth. There is an exceedingly large number of teeth beyond this, of the same type, quite to the exterior margin of the membrane, The teeth are arranged obliquely in waving rows, as is also the case in *Achatinella*, *s. s.* Teeth of same type as those of *Achatinella*, *s. s.*

Tornatellina oblonga, Pease. Huahine Island. Mr. A. Garrett.

Lingual dentition the same as in the preceding species.

Clausilia.

The West Indian species alone examined.

Clausilia tridens, Chemn. Porto Rico. Mr. Robert Swift.

Jaw (Pl. XV, fig. J) slightly arcuate, smooth, wide, low; ends slightly attenuated, blunt; cutting edge with a blunt, wide, median projection. In the jaw figured, the lower margin is developed, but much thinner, beyond the cutting edge.

Lingual membrane (Pl. VII, fig. H) short and broad, with about 30-1-30 teeth. Centrals with long, narrow base of attachment, incurved at the sides and base, where it is also excavated or thinned, rounded at top, and reflected; reflection small, with one large cusp bearing a short, blunt, cutting point, and sub-obsolete side cusps; laterals like centrals, but asymmetrical, the base of attachment much wider, the reflection and cusp with its cutting point much stouter and longer; outer laterals with distinct side cusp and cutting point; the base of attachment of the laterals is squarely cut away on its inner angle; about the eleventh tooth the teeth begin to change to marginals; the extremes of which last are subquadrate, wider than high, broadly reflected into a large cusp bearing two oblique, large, irregularly bifid cutting points.

The figures of the jaw and lingual dentition of this species were photographed from the microscope by my friend, Mr. Samuel Powel, of Newport, to whom I am greatly indebted for assistance in my studies of lingual dentition.

Stenogyra.

See Terr. Moll., V, for dentition of *S. subula*, Pfr., and *decollata*, Lin.

Stenogyra gonostoma, Gundl. Cuba. D. Rafael Arango.

Lingual membrane as in next species.

Stenogyra octona, Chemn. Bahia. J. G. Anthony.

Lingual membrane short and broad.

Teeth about 30-1-30. Centrals with base of attachment long, narrow, angularly expanded at centre; reflection small, bluntly tricuspid, the central cusp bearing a short, stout, cutting point; laterals much larger, as wide as long; reflection very large, with an inner median large, and a small outer cusp on each side of it, all the cusps bearing distinct cutting points; marginal teeth low, wide, irregularly denticulated by minute cutting points. The peculiarity of the dentition, as in the other species of *Stenogyra*, is the small central as well as distinctly tricuspid laterals; the latter are not crowded on the membrane.

Stenogyra hasta, Pfr. Cuba.

Jaw (Pl. XV, fig. I) low, arcuate, ends somewhat attenuated, blunt; no median projection to cutting margin; anterior surface with numerous, vertical, delicate, striæ.

Lingual membrane (Pl. VII, fig. D). Teeth 18-1-18, as usual in the genus. (See Terr. Moll., V.)

Stenogyra juncea, Gld. Island of Huahine. Mr. A. Garrett. Described by Gould and Pfeiffer as a *Bulimus*.

Lingual membrane with 28-1-28 teeth, eight of which on each side are laterals; dentition as in *S. hasta*.

Strophia.

See Terr. Moll., V, for jaw and lingual dentition of *S. incana*.

Strophia decumana, Fér. Castle Island, Bahamas.

Jaw stout, strongly arcuate, ends slightly attenuated, bluntly rounded; anterior surface ribless, transversely striate, and with several stout lines of reinforcement; a small, blunt, median projection to the cutting edge.

Lingual membrane (Pl. VII, fig. A) with 30 1-30 teeth; centrals short, about as broad as long, with short, stout median cusps to the reflection, bearing a stout, broad cutting point, and subobsolete side cusps bearing short cutting points; laterals like the centrals, but bicuspid and asymmetrical; the outer laterals have the inner cutting point bluntly bifid; marginals a modification of the laterals, low, wide, with one inner, large, blunt, bifid cutting point, and one outer smaller.

Strophia mumia, Brug. Abaco, Bahamas.

Jaw slightly arcuate, stout, rough, rather high, ends but little attenuated, blunt; cutting edge with a wide, blunt, slightly developed median projection.

Lingual membrane (Pl. VII, fig, B) with about 30-1-30 teeth, as in the last species. There is a line of reinforcement to the lower margin of the base of attachment of the central and lateral teeth.

Strophia iostoma, Pfr.

Jaw as in other species of the genus.

Lingual membrane (Pl. VII, fig. C) not differing from that of the allied species. Teeth about 29-1-29.

Cionella.

Cionella Gloynei, Gibbons. Curaçao. Mr. J. S. Gibbons.

Jaw and lingual membrane, as usual in *Stenogyra.*

Pl. VII, fig. E, represents the central and first lateral teeth.

Cæcilianella.

Cæcilianella Gundlachi, Pfr. St. Martin. Dr. H. E. Rygersma.

Jaw low, (Pl. XVI, figs. F, G,) wide, slightly arcuate, ends attenuated; whole surface covered with about 22 crowded, broad, flat ribs, denticulating either margin.

Lingual membrane (Pl. VII, fig. F) long and narrow. Teeth 18-1-18, with four perfect laterals. Centrals with their base of attachment long, narrow, their reflected portion about one-half the length of the base of attachment, tricuspid; the middle cusp stout, with a short blunt cutting point, side cusps subobsolete, but with small, distinct cutting points. Lateral teeth with their base of attachment subquadrate, much longer, and very much broader than that of the centrals, the reflected portion short, stout, tricuspid, the middle cusp very stout and long, reaching the lower edge of the base of attachment, beyond which projects the short, stout cutting point; side cusps subobsolete, but bearing distinct, though small cutting points. There are four perfect laterals, the fifth tooth being a transition to the marginals, by the base of attachment being lower, wider, not exceeding the reflected portion, with one inner large cusp bearing one outer large cutting point representing the outer cutting point of the first four lateral teeth and one inner, still larger, cutting point, representing the middle cutting point of the first four laterals, and one smaller, outer cusp, bearing one small, sharp, bifid cutting point, representing the outer side cutting point of the first four laterals. The sixth tooth has the largest cutting point bifid. The balance of the teeth are true marginals. They are very low, wide, with two low, wide cusps, bearing each several irregular, blunt, cutting points.

The dentition of this species is, as would be anticipated, of the same type as the allied *Cæcilianella acicula*, as figured by Lehmann (Lebenden Schnecken Stettins, p. 128, Pl. XIII, fig. 43,) and Sordelli, l. c., fig. 26). The jaw, however, has no appearance of the "brace" like ribs described in that species by Sordelli (Atti Soc. Ital. Sc. Nat., XIII, 1870, 49, Pl. I, fig. 25). The ribs are quite like those figured of *Helix Lansingi* (Terr, Moll., V), although they are narrower.

Lithotis.

Lithotis rupicola, Blandf. Bombay.

Referred by Pfeiffer to *Succinea*, but widely differing from that genus in not having an elasmognathous jaw.

Jaw (Pl. XVI, fig. C) arcuate, with a depression or excavation in the centre of its upper margin; scarcely attenuated towards the ends; cutting edge with a decided median projection; anterior surface with vertical striæ, but no trace of ribs.

Lingual membrane (Pl. VII, fig. G): centrals with long and narrow base of attachment; the reflected portion has one long, median cusp, bearing a long cutting point; laterals like the centrals, but asymmetrical; the outer laterals have a bifid side cutting point; marginals a simple modification of outer laterals.

Limicolaria.

Limicolaria Numidica, Rve.

Jaw thin, highly arcuate, smooth, ends attenuated.

Lingual membrane not examined.

(*b*) Jaw with decided stout ribs.

This section, also, is unsatisfactory, as the species included in it are not all so characterized.

Anadenus.

Anadenus ———? Himalaya Mountains. An undetermined species.

The jaw is thick, low, wide, slightly arcuate; ends but little attenuated; anterior surface with fourteen stout, unequal, separated ribs, denticulating either margin.

On Pl. VII, fig. I, I have figured the lingual dentition of this slug, whose specific name is unknown to me. There are 58-1-58 teeth.

The dentition is of the same type as described in the genus by Heynemann, Malak. Blatt., X, 1863, p. 138.

Carelia.

Carelia bicolor, Jay. Dr. W. H. Dall.

Through the kindness of Dr. Dall, I have been able to examine this species, formerly known as *Achatina bicolor.* Thus I have increased the list of subgenera or groups of *Achatinella* of Gulick's arrangement, whose jaw and lingual dentition is known, leaving still to be examined *Newcombia* only of the same arrangement. (See *ante*, p. 96.)

It will be seen from my description, that while *Carelia* (or at least this species) differs utterly in jaw and dentition from Gulick's *Achatinella*, s. s., *Bulimella, Apex, Partulina, Auriculella*, it agrees in dentition with his *Laminella, Amastra, Leptachatina*, but differs in having a costate jaw. *Carelia*, therefore, must stand distinct from any other groups of *Achatinella.*

The jaw (Pl. XVI, fig. D) is low, slightly arcuate, with but little attenuated, blunt ends; anterior surface with ten stout ribs, denticulating either margin.

Lingual membrane (Pl. VI, fig. I) long and narrow; teeth 37-1-37, of same type as in the species of *Laminella, Newcombia*, and *Leptachatina* (see above), the marginals being irregularly and obliquely pectinate as in *Achatinella obesa.*

Geomalacus.

Geomalacus maculosus, Allm. Ireland. Mr. Gwynn Jeffreys.

Jaw stout, arched, ends not attenuated, blunt; anterior surface with about twelve, broad, crowded ribs, of which four in the centre are more developed and deeply denticulate either margin.

Lingual membrane (Pl. III, fig. H); centrals with long and narrow base of attachment; reflection large, with a stout median cusp bearing a long, stout cutting point; side cusps obsolete; laterals like the centrals, but asymmetrical; marginals to the extreme edge of the membrane a simple modification of the laterals, low, wide, with one inner, long, oblique cutting point, and a smaller, side cutting point.

Veronicella.

See Terr. Moll., V, for a description of jaw and lingual membrane of the genus. The following species agree in lingual dentition :—

Veronicella occidentalis, Guild. Guadeloupe. Mr. Schramm.

Jaw with about 30 ribs.

Veronicella Sloanei. Jamaica.

Jaw with 20 broad ribs.

Veronicella ———. Rio Janeiro, Brazil. J. G. Anthony.

The species undetermined, Body very long and slender.
Jaw with about 30 ribs.
Lingual membrane figured on Pl. III, fig. B.

Veronicella ———. Rio Janeiro. J. G. Anthony.

The species undetermined.
Jaw with 20 broad ribs.

Veronicella ———. Costa Rica. Dr. W. M. Gabb.

An undetermined species. Body long and narrow.
Jaw with from 30 to 40 ribs.

Veronicella ———. Mozambique. Mr. J. S. Gibbons.

An undetermined species.
Jaw with over 22 ribs.

Veronicella olivacea, Stearns. Folvon, Occidental Department, Nicaragua. Mr. McNeil.

Jaw with over 20 ribs.
Lingual membrane, see Terr. Moll., V.

Simpulopsis.

Shuttleworth describes the jaw as having numerous, stout, anterior ribs.

Simpulopsis corrugatus, Guppy. Trinidad. Mr. Guppy.

Jaw not observed.
Lingual membrane (Pl. VII, fig. J) with teeth of same type as figured by Heynemann for *S. sulculosus.* Centrals smaller than the laterals; base of attachment almost as broad as long, its lower margin excavated as in *Succinea;* reflection large, with three cusps and cutting points. Laterals like the centrals, but larger and asymmetrical, the inner, larger cusp of the reflection bearing a very large, expanded, blunt cutting point.

Cryptostrakon.

Cryptostrakon Gabbi, W. G. Binn. Costa Rica. Dr. W. M. Gabb.

Jaw (Pl. XVI, fig. L) high, solid, decidedly arched, ends scarcely attenuated; anterior surface with a few stout ribs, denticulating the lower margin.

Lingual membrane (Pl. VII, fig. K) long and narrow; central teeth tricuspid; laterals bicuspid; marginals quadrate, irregularly bicuspid, the inner cutting points the larger and bifid.

Microphysa.

Microphysa is put in *Helicea* by von Martens. *M. minuscula* (Terr. Moll., V), and *circumfirmata*, Redf., both belong to *Vitrinea*, having aculeate marginal teeth, and jaw of *Zonites*. *M. turbiniformis*, Pfr., has a jaw as in *Cylindrella*, *Bulimulus*, etc., *i. e.*, with numerous very delicate, distant ribs, giving the appearance of separate plates. It would be put in *Goniognatha* of Mörch, though there are no upper triangular median plates. *M. vortex* and *incrustata* (see Terr. Moll., V) have quadrate marginal teeth; the jaw of *incrustata* has numerous, crowded, flat ribs; that of *vortex* was not observed.

Microphysa ? circumfirmata, Redfield.

Jaw not observed.

Lingual membrane long and broad, centrals tricuspid, laterals bicuspid, cusps long and slender, marginals aculeate.

From the above description it will appear that this species belongs to the *Vitrinea* rather than to the *Helicea* of von Marten's arrangement, in which latter it is classed in "Die Heliceen" as a species of the subgenus *Microphysa*. I leave it here, not knowing what else to do with it.

Microphysa turbiniformis, Pfr. Jamaica. Mr. Henry Vendreyes.

Jaw (Pl. XV, fig. C) so extremely thin and delicate as to fold over on itself along its margin and at its extremities; very light horn-colored, almost transparent; strongly arched, attenuated towards its obtuse ends; about forty delicate ribs, such as are found in *Cylindrella*, serrating either margin on about the centre of the jaw is a curving line of reinforcement, somewhat parallel to the lower margin; the upper margin slightly incurved at its centre; the ribs at the centre of the upper margin do not run *en chevron* as do those of *Cylindrella*.

Lingual membrane (Pl. VII, fig. L) long and narrow; teeth about 25-1-25. Centrals large in proportion to the laterals, with a subquadrate base of attachment; three decided, separated cusps and cutting points; laterals tricuspid; marginals low, wide, with both inner and outer cusp bearing an oblique, broad, bifid cutting point.

Fruticicola.

See Terr. Moll., V, for *F. rufescens* and *hispida*.

Fruticicola pubescens, Pfr. Haiti. Mr. V. P. Parkhurst.

Jaw (Pl. XV, fig. H) thin, semitransparent, low, slightly arcuate, ends scarcely attenuated, blunt; upper margin with a strong muscular attachment; no median projection to cutting edge; anterior surface with about twenty ribs denticulating either margin; these ribs appear in most cases to be broad, flat, with narrow interstices, but in others there are appearances such as I have described in *Bulimulus limnæoides* (see below).

Lingual membrane long and narrow (Pl. VI, fig. J). Teeth as usual in the *Helicinæ*. The change from laterals to marginals is very gradual, not formed by the splitting of the inner cutting point. The 12th tooth (figured) shows the commencement of the transition. The 22d (figured) is a marginal tooth. The inner cutting point of the marginals is rarely bifid. Teeth 24-1-24.

Dorcasia.

There is wide variation in the characters of the jaws in this genus. For *D. griseola*, Pfr., see Terr. Moll., V.

Dorcasia similaris, Fér. Brazil. J. G. Anthony.

Jaw arched, ends not attenuated, blunt; anterior surface with eight separated ribs, denticulating either margin.

Lingual membrane (Pl. VI, fig. L) long, with unicuspid centrals and laterals; marginals low, wide, each cusp bifid.

Dorcasia globulus, Müll.

Jaw low, wide, scarcely arcuate, ends not acuminated; no anterior ribs.

Lingual membrane (Pl. VI, fig, M) with about 40-1-40 teeth; teeth with almost square bases of attachment; both centrals and laterals are very distinctly tricuspid; marginals a simple modification of laterals, the broad cutting point trifid.

Both by jaw and lingual dentition this does not agree with the other species of *Dorcasia* examined.

Turricula.

For *T. terrestris*, see Terr. Moll., V.

Turricula tuberculosa, Conr. Palestine. A dried specimen in Mr. Bland's collection.

Jaw with numerous, crowded, broad, flat ribs, denticulating either margin.

Lingual membrane (Pl. VI, fig. N) long and narrow. Teeth 28-1-28; centrals and laterals without decided side cusps or cutting points, but the central cutting point has a decided lateral bulge; marginals low, wide.

with one inner, oblique, large bifid cutting point, and two outer smaller cutting points. A marginal is shown in the figure, with a central and lateral.

Coryda.

Coryda Gossei, Pfr. Jamaica. Messrs. Vendreyes and Gloyne.

Jaw not examined.

Lingual membrane (Pl. V, fig. J) broad; of same type as in *Plagioptycha*.

Plebecula.

Plebecula lurida. Madeira. Dr. Hillebrand.

Jaw low, slightly arcuate, ends scarcely attenuated; anterior surface with about eight broad, separated ribs.

Lingual membrane (Pl. V, fig. K) with tricuspid centrals, bicuspid laterals, all the cusps bearing cutting points; marginals with one, inner, long, oblique, bifid cutting point, and one outer, smaller, bifid cutting point.

Leptaxis.

Leptaxis undata, Lowe. Madeira. Dr. Hillebrand.

Jaw described by Mörch as narrow, with numerous ribs converging to the centre.

Lingual membrane (Pl. VIII, fig. C) of the individual examined, peculiarly abnormal, the malformed teeth as figured being repeated frequently on each transverse row, and down the whole length of the membrane. Such malformations are often found in lingual membranes.

Pomatia.

See Terr. Moll., V, for description of jaw and membrane of *P. aspersa*.

Pomatia Sieboldtiana, Phil. Japan.

Jaw high, arched, ends but little attenuated, blunt; anterior surface with eight stout, separated ribs, denticulating either margin; no median projection to cutting edge. (Pl. XVI, fig. H.)

Lingual membrane (Pl. VIII, fig. B) long and narrow; teeth 39-1-39, with 21 perfect laterals on each side of the median line; base of attachment of centrals long and narrow, reflection broad, with stout median cusp and cutting point; side cusps and cutting points wanting; laterals like the centrals, but asymmetrical, the fifteenth lateral is the first with the side cutting point; marginals low, wide, with one broad, oblique, bluntly bifid cutting point, and one side, short, cutting point.

The species was put by von Martens in *Acusta*, a sub-genus of *Nanina*.

Pomatia Humboldtiana, Val. Mexico. Dr. E. Palmer.

Jaw short, arched, bluntly ending; with six broad, separated, stout ribs, denticulating either margin.

Lingual membrane (Pl. VIII, fig. A) with shorter, stouter teeth than in the last species. The centrals are pear-shaped, with no side cusps or cutting points.

Thelidomus.

Jaw with stout anterior ribs.

Lingual membrane the same in the species examined, in general characteristics, but there will be found variation as to the presence of side cutting points on centrals and laterals.

Thelidomus aspera, Fér. Jamaica. Mr. V. P. Parkhurst.

Jaw wide, low, arcuate, ends but slightly attenuated, blunt; anterior surface with eight sharp, prominent ribs, strongly denticulating either margin.

Lingual dentition (Pl. VIII, fig. E) long and narrow. Teeth 41-1-41. Centrals and laterals with stout broad cusps and cutting points; no side cusps or cutting points; marginals with one long, bluntly bifid cutting point.

Thelidomus discolor, Fér.

Jaw arcuate, thick, ends blunt. Anterior surface with seven unequal, decided, stout ribs, denticulating either margin.

Lingual membrane (Pl. VIII, fig. D) long and narrow. Centrals with a long narrow base of attachment expanded at the base, and bearing at its corners a small reinforcement; lower margin extending beyond the cusp; reflection bluntly tricuspid, the median cusp long, stout, with a short blunt point; side cusps subobsolete. Laterals as the centrals, but asymmetrical, and with a shorter base of attachment. Marginals quadrate, wide as high, with two short, blunt denticles, the inner one slightly the longer.

Thelidomus auricoma, Fér. Lomas de Camoa, Cuba. Mr. Arango.

Jaw arched, with blunt, scarcely attenuated ends; twelve broad ribs distributed over the whole anterior surface and denticulating either margin.

Lingual membrane (Pl. VIII, fig. F) with 42-1-42 teeth, of which 25 may be called laterals, but the change is gradual into marginals. Teeth as in *provisoria.*

Thelidomus notabilis, Shuttl. Tortola. Mr. Robert Swift.

Jaw arcuate, low, ends blunt, narrower at the centre; decided separate ribs denticulating either margin.

Lingual membrane (Pl. VIII, fig. G). Centrals tricuspid; laterals bicuspid; the base of attachment about as wide as high, the larger cusp with a long cutting point extending beyond the lower margin of the base of attachment.

Marginals quadrate, of equal width and height, with two short, wide, blunt, round cusps, the inner one slightly the larger.

Thelidomus lima, Fér. Porto Rico. Mr. R. Swift.

Jaw arcuate, ends blunt; anterior surface with seven stout ribs; a strong muscular attachment.

No lingual membrane examined.

Thelidomus Jamaicensis, Chemn. Jamaica. V. P. Parkhurst.

The species is placed in *Liochila* by von Martens, but Mr. Bland places it in this genus.

Jaw thick, arcuate, ends attenuated; anterior surface with 14 decided but unequal ribs, irregularly disposed and denticulating either margin.

Lingual membrane (Pl. VIII, fig. H) long and narrow, with 41-1-41 teeth; there are no distinct side cusps and cuttting points on the centrals and inner laterals.

Thelidomus provisoria, Pfr. New Providence, Bahamas. Gov. Rawson.

Jaw very slightly arcuate, wide, low, of equal height throughout to its blunt ends; anterior surface with 10-15 ribs, separated by irregular intervals, not always reaching the cutting edge, which has a broad, blunt, median projection.

Lingual membrane (Pl. VIII, fig. I) with 40-1-40 teeth; the centrals and laterals have a distinct side cutting point.

Eurycratera.

Eurycratera angulata, Fér. Porto Rico. Mr. R. Swift.

Jaw stout, dark claret-colored, low, wide, ends blunt; about seven very wide, very crowded ribs, bluntly denticulating either margin.

Lingual membrane (Pl. VIII, fig. J); central and laterals with distinct side cutting points.

Eurycratera crispata, Fér. San Domingo. Dr. Newcomb.

Jaw thick, arcuate, ends blunt; anterior surface with ten stout ribs.

Lingual membrane (Pl. VIII, fig. K). Centrals and laterals with the upper margin of the base of attachment produced into angles as below, with distinct side cutting point; middle cutting point of centrals and inner cutting point of laterals greatly produced.

Polydontes.

No jaw of this genus examined.

Polydontes Luquillensis, Shuttl.

Lingual membrane (Pl. VIII, fig. L) as usual in the *Helicidæ.* Centrals tricuspid, laterals bicuspid; cusps wtih long, sharp cutting points, extending beyond the base of attachment; marginals bicuspid, cusps short, bluntly rounded, the inner one, as usual, the longer, each bearing short cutting points.

Stylodon.

I have shown *H. militaris*, Pfr., placed in this genus by von Martens, to be a *Nanina*.

Stylodon Studeriana, Fér. Seychelles. Consul Pike.

Jaw stout, strongly arched, ends but little attenuated, blunt; anterior surface without ribs; there are, however, a few coarse, broad, vertical wrinkles. One jaw had a slightly developed median projection to its cutting edge, another has no approach to a projection.

Plate VIII, fig. M, shows the lingual dentition; teeth 69-1-69, with about 22 laterals on each side. There is considerable resemblance to the dentition of *Merope fringilla* described below. The cutting points on centrals and laterals are, however, more pointed. There are no side cusps or cutting points to centrals or inner laterals; the outer laterals and marginals have very oblique, broad, bluntly trifid cutting points.

Dentellaria.

In this genus, the presence or absence of ribs on the jaw is not a reliable generic character.

I have examined a large proportion of the known species. The jaw varies somewhat, so that each description should be studied. There seems a tendency to a median projection to the cutting edge, and to the presence of ribs. *D. pachygastra*, Gray, has seven decided ribs and no median projection; *orbiculata*, Fér., has traces of ribs and no median projection; *Isabella*, Fér., has decided ribs and no median projection; *dentiens*, Fér., has decided ribs and no median projection; *nucleola*, Rang., has one decided rib and a median projection; *badia* has eight decided ribs; *formosa*, Fér., has no ribs, but a strong median projection; *perplexa*, Fér., has obsolete ribs and median projection: *lychnuchus*, same as last; *punctata*, Born, has median projection and decided ribs; *Josephinæ*, Fér., is strongly arched, has no ribs, but a median projection.

The species agree in their dentition.

Dentellaria orbiculata, Fér.

Jaw striated, thick, slightly arched, ends squarely truncated; cutting edge irregular, showing traces of the ends of subobsolete ribs, no median projection. (Pl. XVI, fig. W.)

Lingual membrane (Pl. IX, fig. A) long and broad, with 47-1-47 teeth. Base of attachment long and narrow in centrals, a line of reinforcement near its upper margin ; reflected portion small, stout, with a short, stout median cusp bearing a short, stout cutting point, no side cusps or cutting points; first laterals like the centrals, but asymmetrical; outer laterals with side cusp and cutting point ; marginals low, wide, with one large, inner bluntly bifid cutting point and one outer small bifid cutting point.

Dentellaria Isabellæ, Fér. Barbadoes. Gov. Rawson.

Jaw striated vertically and horizontally, with about eight well-defined ribs denticulating either margin.

Lingual membrane (Pl. IX, fig. B) as above.

Dentellaria dentiens, Fér. Dominica. Mr. Guppy.

Pl. IX, fig. C, gives full details of the changes of the teeth from centrals to marginals, especially the side cusp and cutting point of the outer laterals, and the transition from laterals to marginals; teeth 33-1-33.

Jaw (Pl. XVI, fig. N) with 4-5 stout ribs denticulating either margin.

Dentellaria nucleola, Rang. Martinique. Gov. Rawson.

Jaw thick, arched, ends blunt; cutting margin with an obtuse median projection ; one central, stout rib, denticulating either margin. (Pl. XVI, fig. O.)

Lingual membrane as usual in *orbiculata*. (Pl. IX, fig. D.)

Dentellaria nuxdenticulata, Chemn. Martinique. Gov. Rawson.

Jaw (Pl. XVI, fig. V) stout, arched, ends blunt; blunt median projection to cutting edge; one stout, well-developed rib on the centre of the jaw, and three less developed, separated, on either side of it.

Lingual membrane (Pl. IX, fig. E) as in the other species.

Dentellaria pachygastra, Gray. Guadeloupe. Mr. Schramm.

Jaw (Pl. XVI, fig. P) stout, slightly arcuate, ends blunt; anterior surface with about seven irregularly disposed ribs; both ends free from ribs.

Lingual membrane (Pl. IX, fig. F) as in the other species.

Dentellaria badia, Fér.

Jaw stout, arched, ends blunt; eight decided ribs. (Pl. XVI, fig. Q.)

Lingual membrane (Pl. IX, fig. G) as in other species.

Dentellaria formosa, Fér. Antigua. Mr. Robert Swift.

Jaw arched; ends blunt ; several strong, transverse lines of reinforcement, but no ribs; a median projection to cutting edge. (Pl. XVI, fig. R.)

Lingual membrane as usual in the genus. (Pl. IX, fig. H.)

Dentellaria Josephinæ, Fér. Guadeloupe. Mr. Schramm.

Jaw (Pl. XVI, fig. S) stout, ribless, horseshoe-shaped, ends bluntly rounded; a decided median projection to the cutting edge, marked with strong vertical striæ.

Lingual membrane as in other species. (Pl. IX, fig. I.)

Dentellaria perplexa, Fér. Island of Grenada. Gov. Rawson.

Jaw with a median projection to its cutting edge, The anterior surface is of irregular thickness, showing some approach to the ribbed form of jaw. (Pl. XVI, fig. T.)

Lingual membrane as usual. Central and lateral teeth with short, stout, blunt cusps. Marginal teeth quadrate, with one wide, stout, bluntly rounded median cusp, and two small, blunt side cusps. (Pl. IX, fig. J.)

Dentellaria lychnuchus, Müll. Guadeloupe. Mr. A. Schramm.

Jaw (Pl. XVI, fig. U) arched, ends blunt, cutting margin with a broad, blunt, median projection; strong vertical striæ and transverse lines of reinforcement, and subobsolete ribs, which denticulate the upper margin.

Lingual membrane as in the other species. (Pl. IX, fig. K.)

Pleurodonta.

The jaw is decidedly costate. Lingual membrane much as in *Plagioptycha* and *Dentellaria.*

Pleurodonta acuta, Lam. Jamaica.

Jaw arched, thick, ends blunt, attenuated; anterior surface with seven distant, stout ribs, denticulating either margin.

Lingual membrane (Pl. X, fig. A) with 40-1-40 teeth as above; the marginal figured has only one long, oblique cutting point.

Pleurodonta Chemnitziana, Pfr. Jamaica. Mr. Robert Swift.

Jaw stout, arched, ends attenuated, blunt; anterior surface with about six irregularly disposed ribs, stout and denticulating either margin.

No lingual membrane received.

Pleurodonta Carmelita, Fér. Jamaica. Mr. Robert Swift.

Jaw arcuate, ends blunt, anterior surface with about six stout ribs, denticulating either margin.

Lingual membrane (Pl. X, fig. B) as usual in the genus. Central teeth short, bluntly pointed on the middle cusps, the side cusps subobsolete; laterals like centrals, also with obsolete side cusps and cutting points; marginals low, wide, with an inner large, oblique, bluntly trifid cutting point.

Pleurodonta Schroeteriana, Pfr. Jamaica. Mr. Vendreyes.

Jaw not examined.

Lingual membrane (Pl. X, fig. C) as in other species.

Pleurodonta invalida, Ad. Jamaica. Mr. Henry Vendreyes.

Jaw not examined.

Lingual membrane (Pl. X, fig. D) as in the other species. Centrals and laterals short and stout.

Merope.

Merope fringilla, Pfr. Admiralty Island. Prof. A. G. Wetherby.

The dried remains of the animal in the shell of a cabinet specimen furnished the lingual membrane and jaw here described. The shell is the variety with the pink peristome.

Jaw with numerous crowded, stout ribs, denticulating either margin.

Lingual membrane (Pl. X, fig. E) long and narrow; teeth 28-1-28, with about 11 laterals. Centrals with base of attachment longer than wide; side cusps obsolete, side cutting points wanting; middle cusp broad, blunt, with a very short, broad, blunt cutting point. Laterals like the centrals, but asymmetrical; the cutting point becomes longer as they pass off laterally, and at the 12th tooth it commences to be bluntly trifid. The marginals are peculiar; their base of attachment is subquadrate, with a single broad cusp, bearing a very broad, oblique, expanding, trifid cutting point; the outer division very small, pointed; the median longer, very broad, squarely truncated; the inner one about half the size of the median, recurved and sharply pointed.

The left hand figure in the plate shows a marginal in profile.

The dentition of this species is peculiar, resembling that common in *Orthalicus* rather than the type usual in *Helix*.

Helix, ———. Costa Rica. Dr. W. M. Gabb.

Jaw not observed.

Lingual membrane (Pl. V, fig. L) long and narrow. Teeth 15-1-15. Centrals with a base of attachment longer than wide, with lower lateral expansions; reflection large, decidedly tricuspid, each cusp surmounted by a cutting point. Laterals like the centrals, but asymmetrical and consequently bicuspid. Marginals low, wide, irregularly denticulated or serrate, the inner three cutting points being longer than the outer ones, of which there are several.

Helix astur, Souv. I do not know the position of this species. New Caledonia.

Jaw (Pl. XVI, fig. B) low, wide, slightly arcuate, ends scarcely attenuated, blunt; anterior surface without ribs; a wide, blunt, median projection to the cutting edge; a line of reinforcement running parallel to the cutting margin; a strong muscular attachment to the upper margin.

Lingual membrane (Pl. X, fig. F) with 30-1-30 teeth, nine perfect laterals on each side; teeth as usual in the *Helicidæ;* with decided side cusps and cutting points.

Helix convicta, Cox. Australia. Dr. Cox.

Subgeneric position unknown to me.

Jaw highly arcuate, thick, ends blunt; anterior surface with seven separated, stout ribs, denticulating either margin.

Lingual membrane (Pl. X, fig. G) with 30-1-30 teeth, ten laterals on each side; centrals and inner laterals without side cutting points; marginals low, wide, with one inner, large, oblique bifid cutting point, and one smaller side cutting point.

Cochlostyla.

The only subgenus examined is *Canistrum*, and this only in one species:—

Canistrum fulgetrum, Brod.

Jaw arcuate, thick, wide, low, ends but slightly attenuated, blunt; anterior surface with more than twelve stout, broad ribs, denticulating either margin.

Lingual membrane (Pl. XI, fig. G) long and broad. with 80-1-80 teeth; centrals and inner laterals without side cusps and cutting points, the reflection and cusp stout, the cutting point blunt; marginals with greatly produced, bluntly pointed upper margin to the base of attachment.

Bulimus.

Of this genus species of several subgenera were examined.

Macrodontes odontostomus, Sowb.

Jaw wide, low, slightly arched, smooth.

Lingual dentition (Pl. X, fig. H). Teeth 34-1-34; the cusps and cutting points are short and stout; no side cusps or cutting points.

Pelecychilus auris-Sileni, Born. St. Vincent.

Jaw with delicate, distant ribs, as in *Cylindrella*, q. v.

The cutting points on the teeth of the lingual membrane are very long. (Pl. X, fig. I). The upper, as well as lower, lateral angles of the base of attachment in the centrals and laterals are greatly developed.

Pelecychilus glaber, Gmel. Island of Grenada, W. I.

Jaw as in last species.

Lingual membrane (Pl. X, fig. J) with decided side cusps and cutting points to all the teeth.

Anthinus multicolor, Rang.

Jaw thick, greatly arched, ends attenuated, striate; no anterior ribs; no median projection to cutting edge.

Lingual membrane (Pl. XI, fig. A) with 40-1-40 teeth; base of attachment very long, reflection small, with a short blunt cutting point; no side cusps or cutting points.

Pachyotus egregius, Jay. Brazil. J. G. Anthony.

Jaw not examined.

Lingual membrane (Pl. XI, fig. B); the upper margin of the base of attachment is carried beyond the reflection in the centrals; teeth stout, with stout cusps and cutting points.

Borus oblongus, var. *albus,* Müll. Tobago. Gov. Rawson.

Jaw slightly arcuate, stout, wide, of almost equal height throughout; ends but slightly attenuated, blunt; anterior surface with vertical and transverse striæ and perpendicular wrinkles, scarcely distinguishable from the ribs, of which there are ten well-developed, crenulating either margin.

Lingual dentition as published by Heynemann for *B. oblongus* in Mal. Blatt., 1868.

Orphnus Hanleyi, Pfr. Brazil. J. G. Anthony.

Jaw stout, strongly arched, transversly striate; ends but little attenuated, blunt; cutting edge with a broad, stout, striated median projection.

Lingual membrane (Pl. XI, fig. D) long and narrow; teeth 50-1-50; the lower margin of the base of attachment is excavated in centrals and laterals; no side cusps or cutting points.

Orphnus foveolatus, Rve. Northern Peru. Prof. Orton.

Jaw slightly arched, wide, low, thin, with over 50 delicate ribs of the kind described below under *Bulimulus Lobbi,* Rve.

Lingual membrane (Pl. XI, fig. C) long and narrow, with 34-1-34 teeth; no side cusps or cutting points to centrals and laterals; reflection short, stout; the membrane is of the same width to its abruptly truncated ends, and very thick.

Orphnus magnificus, Grat. Brazil.

Jaw stout, low, wide, slightly arched, ends slightly attenuated, blunt; entire anterior surface covered with numerous stout ribs, breaking the regularity of both upper and lower margin, but not actually denticulating them.

Lingual membrane long, rather broad, with 30-1-30 teeth. Teeth as in *O. Hanleyi.*

Dryptus pardalis, Fér.

Jaw thick, low, wide, slightly arcuate, ends but slightly attenuated, blunt; whole anterior surface occupied by 12 broad ribs, denticulating either margin.

Lingual membrane not examined.

Dryptus marmoratus, Dunker.

Lingual membrane (Pl. XI, fig. E) long and broad; no side cusps or cutting points.

Eurytus aulacostylus, Pfr. St. Vincent. Gov. Rawson.

Jaw thin, transparent, slightly arcuate, with about sixty delicate ribs, as found in *Cylindrella;* no upper median ribs *en chevron,* but all the ribs slightly oblique.

Lingual membrane (Pl. XI, fig. F); centrals tricuspid, laterals bicuspid, each cusp with long cutting point.

(c) JAW WITH SEPARATE, DELICATE RIBS, USUALLY RUNNING OBLIQUELY TOWARDS THE CENTRE.

Several species are found in the last genus with this type of jaw.

Gæotis.

The genus *Gæotis* was described by Shuttleworth,* founded on a curious mollusk from Porto Rico. The lingual dentition was said by him to be nearly the same as in *Vitrina* and *Zonites,* the teeth arranged in oblique rows, centrals obtusely tridentate, laterals scarcely differing from the centrals, marginals lengthened, awl-shaped, arcuate, at base ? bifurcate. The presence of a jaw was not verified by Shuttleworth. The character of the dentition was considered such as to denote carnivorous habits of the animal.

An examination of an unidentified Porto Rico specimen (Mr. R. Swift) has furnished the following description.

Gæotis ———.

Jaw (Pl. XV, fig. A) long, low, slightly arcuate, ends attenuated, extremely thin and delicate, transparent; in one single piece, but divided by over forty† delicate ribs into as many plate-like compartments of the type common in *Cylindrella* and *Bulimulus,* but with no upper median triangular space; the ends of the ribs serrate the upper and lower margins.

Lingual membrane (Pl. XI, figs. H, I) long and broad, composed of numerous rows of teeth arranged *en chevron.* Centrals with base of attachment very long, narrow, obtuse above, incurved at sides, obtusely rounded and expanded at base, near which is a short, gouge-shaped, expanded cusp, whose lower edge has three bluntly-rounded cutting points. Laterals same as centrals in shape, but a little larger, and asymmetrical from the disproportionate expansion of the cutting point. Marginals same as laterals, but more slender, with more developed and graceful cutting points, of

* Férussac's figure of *Parmacella palliolum* seems to show a jaw with stout ribs; I do not think *Gæotis* can belong to the same genus, *Peltella.*

† Fragments only of the jaw were saved; the largest one I have figured, and from it estimate the whole number of ribs.

which the median is pointed, often bifid. There is much variety in the shape and denticulation of the cusps. The middle denticle is always the smallest. Teeth aculeate when seen in profile.

By its jaw, *Gæotis* calls to our mind the genua *Amphibulima*, and many species of *Bulimulus* and *Cylindrella*. There is some resemblance in its lingual dentition to the marginal teeth of *Orthalicus* and *Liguus*, as well as of *Polymita muscarum*. It also forcibly reminds one of some of the features of the dentition of *Tribonioph orus*.

Amphibulima.

Amphibulima patula, Brug. Dominica. St. Kitts.

Jaw (Pl. XV, fig. E) slightly arcuate, low, ends attenuated: extremely thin and transparent, with prominent transverse striæ, divided longitudinally by about forty-five delicate ribs into so many plate-like sections of the same character as those of *Cylindrella*, *Macroceramus*, and many species of *Bulimulus*. No upper triangular median plates as in *Cylindrella*. Margin serrated by extremities of ribs.

Lingual membrane (Pl. XIII, figs. C, D) from a specimen from Dominica, long and broad, composed of numerous horizontally-waving rows of teeth, of the form usual in the *Helicidæ*. Centrals with subquadrate base of attachment extended at basal angles, narrowing towards the centre, expanding towards the upper edge, which is reflected and tricuspid, extending quite to the base of the tooth; the cusps are stout, the median one bluntly pointed, each bearing a cutting point. The lateral teeth are of the same type as the centrals, but asymmetrical. The marginals are long and narrow, rounded at base, narrowed at apex, reflected and bicuspid; cusps short, stout, bearing a cutting point, and generally a simple modification of those of the laterals. The extreme marginals have irregular cutting points, like simple papillæ. Fig. D shows a group of laterals. Fig. C shows the changes from centrals to extreme marginals.

Pl. XIII, fig. A, shows the dentition of the St. Kitts form, fig. B giving a group of laterals.

Lately the question of identity of these shells with the Guadeloupe *patula* has been raised (see Journal de Conchyliologie, XXI, 12). I have, therefore, again carefully examined the lingual membranes previously described, to learn if they give any difference worthy to be considered of specific value. I have figured teeth from each lingual membrane. I regret not having had the opportunity of examining Guadeloupe specimens also, but have never been able to receive the latter with the animal; indeed it seems to be now found subfossil only.* I can only treat the question of the identity of the St. Kitts and Dominica forms, not their identity with Guadeloupe forms.

It will be seen that the Dominica form has sharper cutting points to the large cusps of its central and lateral teeth than that of St. Kitts. Fig. B shows a group of laterals of the former, in which some variation from the pointed shape is indeed shown, but no decided tendency that way. On the other hand, the laterals, from the St. Kitts form, show great constancy in the square truncation of the cutting points. (Fig. B.)

The teeth of the St. Kitts form are broader in proportion to their length than those of Dominica, have a greater curve in their outlines, and more developed side cusps, which overlap the median cusps.

The Dominica lingual in the only row counted had 87-1-87 teeth. A row of the St. Kitts form had 57-1-57. The marginal teeth of the St. Kitts form show a greater tendency to splitting into sharp denticles on the cutting cusps than those of Dominica.

It cannot be denied that certain variations may be noticed in the two lingual membranes. I believe, however, that these differences are not such as suggest specific distinction, especially as the shell furnishes no grounds for doubting the specific identity of the forms.

Mr. Bland has given a detailed account of the species in Journal de Conchyliologie, XXI, 342, October, 1873.

Amphibulima Rawsonis, Bl. Isle of Montserrat, between Nevis and Guadeloupe. Gov. Rawson.

Jaw as in *A. rubescens*, about 33 ribs; those at the upper centre running obliquely and meeting or ending before reaching the lower margin.

Lingual membrane (Pl. XIII, figs. H, G) as usual in the genus. Centrals with the base of attachment very much larger than that of the laterals, and with an enormous, single, broad, long, rapidly and obtusely pointed cutting point. No side cusps or side cutting points. Laterals of the form usual in the *Helicinæ*, with a stout, inner cusp, bearing a broadly truncated, short cutting point, aud a small side cusp bearing a short cutting point.

The change from laterals to marginals is shown in the 10th, 15th and 27th teeth in the plate.

The marginals (28th and 68th teeth in the plate) have a long, narrow base of attachment, which near its lower margin bears a short, slightly expanding, bluntly trifid cusp; from this cusp springs a short, expanding, bluntly denticulated, broad, cutting edge, the inner denticle the largest. This cutting edge is shown in the 67th and 68th teeth on a more enlarged scale, There is great variation in the denticulation of the cutting edge. There are 68-1-68 teeth.

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* See, also, under *A. Rawsonis*, for Fischer's description of the dentition of the Guadeloupe form.

The peculiarity of this membrane is the enormous development of the central tooth.

Fig. G shows a lateral in profile: I have given figures of the dentition of *A. patula*, Brug., of St. Kitts and of Dominica, of *A. appendiculata*, Pfr., of Guadeloupe, and of *A. rubescens*, Fér., of Martinique. Dr. Fischer (Journ. de Conch., XXII, 1874, Pl. V) figures that of *A. depressa* of Guadeloupe. and *A. patula* of Guadeloupe.

Dr. Fischer also (l. c.) figures the dentition of *A. rubescens*. He gives inner side cutting points to the lateral teeth, which I did not find in my specimens. His figure of the dentition of the Guadeloupe *A. patula* is certainly specifically distinct from the St. Kitts and Dominica form. It seems as if there were the following distinct species of *Amphibulima: depressa, appendiculata, rubescens, patula* of Guadeloupe, *patula* of St. Kitts and Dominica, and *Rawsonis*.

Amphibulima rubescens, Desh. Martinique. Gov. Rawson.

The jaw is readily detached from the muscles of the mouth, and is not connected with the lingual membrane as usual with our *Helices*.* It is thin, wide, low, arched, with attenuated, bluntly pointed ends, divided by numerous (about 63) delicate ribs into separate plate-like divisions, as in the jaw of *Cylindrella. Bulimulus*, etc., the ribs running somewhat obliquely towards the centre of the jaw; there is no decided, upper median, triangular plate. (Pl. XV, fig. D.) The lingual membrane (Pl. XIII, fig. F) is long, broad, composed of numerous rows of 76-1-76 teeth. Centrals long, narrow, expanding below, with the lower margin of the base of attachment squarely excavated as in *Succinea;* tricuspid, the central cusp very long, wide, with a greatly expanded, squarely truncated cutting point reaching beyond the lower margin of the base of attachment; the side cusps short and narrow, simply pointed. The lateral teeth are of same type as the centrals, but asymmetrical and bicuspid. The marginals are a simple modification of the laterals, with a long, bluntly truncated median cusp, and obsolete side cusps. The extreme marginals are irregularly denticulated, the outer and inner denticles being more produced, especially the outer, and greatly curved; the inner denticles, usually two in number, are quite small.

Amphibulima appendiculata, Pfr. Guadeloupe. Gov. Rawson.

Jaw (Pl. XV, fig. F) extremely thin and transparent, long, low, slightly arcuate, ends blunt, divided longitudinally by about 40 regular ribs into as many

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* Even after boiling the whole buccal mass in potash, the lingual membrane and jaw remain attached in most of our *Helices* of N. A. showing a decided connection between the two.

See last species for remarks on Dr. Fischer's description and figure of the dentition of the species.

plate-like sections, of the character found in the jaws of *Cylindrella*, *Macroceramus*, and many species of *Bulimulus*. No appearance of triangular upper median plates, however, as in *Cylindrella*, though the two specimens examined by me are not perfect at that part. Both margins serrated by the extremities of the ribs. The jaw is quite membranous.

Lingual membrane (Pl. XIII, fig. E). Centrals subquadrate with a very large, stout, short, pointed cusp, the side cusps obsolete. Laterals larger and more narrow than the centrals, bicuspid, the inner cusp greatly produced, broad and quite squarely terminating. The base of attachment of the laterals is cut away on the inner side, leaving a large outer lateral expansion, bringing to mind the much less developed one of *Succinea*. Marginal teeth quadrate, gradually becoming modified from the laterals, the cusps finally passing off into simple, obtuse papillæ, the inner one the larger.

Bulimulus.

The species of this genus may be grouped by their lingual dentition, independently of the character of the shell, into (*a*) those having the type of teeth usual in the *Helicidæ*, and (*b*) those having the peculiar type of dentition figured on Pl. XII, fig. G (see *B. primularis*), and (*c*) those having the dentition of *B. Lobbi*. (Pl. XIV, fig. E.) The former two types are found in several of the subgenera noticed below.

The jaw of *Bulimulus* is usually thin, with delicate, separated ribs as in *Cylindrella*, their ends serrating either margin; the ribs at the upper centre of the jaw often run obliquely and terminate before reaching the lower margin.

Drymæus altoperuvianus, Rve. Between Balsas and Cajamarca, Peru. Prof. Orton.

Jaw with 31 ribs, delicate, separated, as in *Cylindrella*.

Lingual membrane (Pl. XIV, fig. F) very peculiar, resembling that of *B. Lobbi*, described below, excepting that the marginal teeth are of same type as the laterals, with still more produced cutting point; one in profile is shown in the left-hand figure.

Drymæus Vincentinus, Pfr., var.? Tobago.

Jaw as usual in *Bulimulus*, thin, transparent, with numerous delicate, separated, narrow ribs.

Lingual membrane as in *Bulimulus laticinctus*. (See below.)

Drymæus Knorri, Pfr. Porto Cabello, Venezuela. Mr. Robert Swift.

Jaw arched, high, ends attenuated, blunt; an obtuse median projection to cutting edge; transverse lines of reinforcement, but no ribs.

An unusual form of jaw in this genus, though common in many subgenera of *Helix*.

Drymæus Lobbi, Rve. Between Balsas and Cajamarca, Peru. Prof. Orton.

Jaw (Pl. XV, fig. P) thin, transparent, as usual in the genus, with 21 narrow, distant ribs, serrating either margin, running obliquely towards the centre of the jaw, so that those of the upper centre meet or end before reaching the lower margin; the substance of the jaw is so thin that it divides, on maceration, into separate pieces at the ribs; in some specimens the jaw seemed to be formed of distinct plates, whose overlapping forms the ribs; I have no doubt, however, that it consists of one single piece.

Lingual membrane (Pl. XIV, fig, E) broad, very delicate in texture, and difficult to handle; numerous rows of 90-1-90 teeth; the centrals have the base of attachment longer than wide, with lower lateral expanded angles; the reflection has one stout, median cusp, the side cusps being obsolete; this cusp bears a short, rapidly attenuated, sharp cutting point; the laterals are of same type as centrals, but differ widely in the cutting point, which is oblique, extremely long, broad as the upper margin of the base of attachment, bluntly rounded at its end, near which on the inner side is a prominent, blunt notch; the marginals are low, wide, with a very oblique cusp, bearing a much broader, trifid cutting point, the middle one much the largest, all with curving sides.

Drymæus Bahamensis, Pfr. New Providence, Bahamas. Gov. Rawson.

Jaw as usual in the genus, over fifty ribs ; in some specimens the ribs at the centre meet or end before reaching the lower margin, so oblique are they; in others they are so slightly oblique as to reach and serrate the lower margin.

Lingual membrane (pl. XII, fig. F) with no lateral teeth, all the side teeth being marginals of the form described in *B. Lobbi.*

Drymæus Rawsonis, H. Ad. Tobago. Gov. Rawson.

Lingual membrane as in last species.

Liostracus multifasciatus, Lam. Antigua. Gov. Rawson.

Jaw as usual in the genus.

Lingual membrane as in last species ; the cusp of the central tooth has three cutting points. The marginals are in waving rows.

Liostracus alternans, Beck. Islands in the Bay of Panama. Mr. McNeil.

Jaw as usual in the genus, 52 ribs.

Lingual membrane as in last species.

Liostracus Marielinus, Poey.

See Terr. Moll., V.

Mesembrinus primularis, Rve. Northern Peru. Prof. Orton.

Jaw as usual in the genus.

Lingual membrane (Pl. XII, fig. G) as in last species, but there is only one cutting point in the central tooth.

Mesembrinus pallidior, Sowb.

See Terr. Moll., V.

Lingual membrane as in the following, not as in last species.

Mesembrinus chrysalis, Pfr. Martinique. Gov. Rawson.

Jaw of the type common in *Bulimulus*, *Cylindrella*, etc., arcuate, low ; ends blunt ; thin, transparent ; with eighteen narrow, separated ribs ; a transverse central line of reinforcement. Attached to the upper margin is a strong triangular membrane of the same consistence and material as the jaw itself, and equally resisting the action of potash, so as readily to be mistaken for the accessory plate of the *Succineæ*. (Pl. XV, fig. Q.)

Lingual membrane (Pl. XIV, fig. G) as usual in the *Helicinæ*. Centrals about as broad as long, tricuspid, and median cusp short and stout, its short point not extending to the base of the plate. Laterals like the centrals, but bicuspid. Marginals wide, low, with one inner, long, blunt, stout, oblique denticle, and one or two short, blunt side denticles.

Thaumastus immaculatus, Ad. Jamaica. Mr. Gloyne.

Jaw as usual in *Bulimulus* ; over 36 ribs.

Lingual membrane (Pl. XII, fig. H) as in *Bul. chrysalis* ; central teeth with three cutting points.

Mormus membranaceus, Phil. Brazil. J. G. Anthony.

Jaw as usual ; with about 24 ribs.

Lingual membrane as in *Bul. chrysalis*.

Mormus laticinctus, Guppy. Dominica. Mr. Guppy.

Jaw not examined.

Lingual membrane (Pl. XII, fig. I) as in *Bul. Bahamensis;* the transverse rows of teeth in this type of membrane are waving.

Mormus sufflatus, Gld.

Jaw as usual in *Bulimulus;* about 21 ribs.

Lingual membrane as in *B. chrysalis.*

Mormus Jonasi, Pfr.

Jaw as usual in *Bulimulus.*

Lingual membrane as *B. Bahamensis.*

Scutalus rhodolarynx, Rve. Northern Peru. Prof. Orton.

Jaw ruined by the action of potash.

Lingual membrane (Pl. XII, fig. D) as in *B. chrysalis;* long and narrow; teeth 40-1-40.

Scutalus proteus, Brod. Northern Peru. Prof. Orton.

Jaw as usual; 28 ribs.

Lingual membrane as in *B. altoperuvianus.*

Leptomerus limnœoides, Fér. St. Kitts. Dr. Branch.

Jaw (Pl. XVI, fig. I) low, wide, semitransparent, slightly arcuate, ends scarcely attenuated, blunt; anterior surface with about sixteen ribs, denticulating either margin. It is extremely difficult to decide upon the character of these ribs. Some appear to be a simple thickening of the jaw, formed by the overlapping of distinct separate plates. Others remind me of the distant narrow ribs of most of the *Bulimuli*, of the character of the ribs in *Cylindrella*, etc. At other points upon the jaw there seem to be broad, flat ribs with narrow interstices.

Lingual membrane long and narrow (Pl. XII, fig. E). Teeth as usual in the *Helicinæ*. The change from laterals to marginals is very gradual, the latter being but a modification of the former, with two cutting points, the inner the longer. Thus it appears that this species in its dentition agrees with *B. cinnamomeo-lineatus, pallidior, chrysalis, dealbatus, Guadalupensis, alternatus, sporadicus, solutus, sepulcralis, durus, Peruvianus, rhodolarynx*, and not with *laticinctus, Bahamensis, auris-leporis, papyraceus, Jonasi, membranaceus, trigonostomus, flavidus, virginalis, convexus, Vincentinus, Lobbi, alternans, multifasciatus, primularis.*

Teeth 30-1-30, with about ten laterals on each side. The outer cutting point of the marginals is sometimes bifid.

Leptomerus sepulcralis, Poey. New Providence, Bahamas.

Jaw stout, wide, low, arcuate, of about equal height throughout, ends bluntly rounded; anterior surface with 15 stout, broad, crowded ribs, their ends crenulating either margin; some of these ribs are of equal thickness throughout, and are separated by decided, narrow interstices; the jaw cannot, therefore, be said to resemble that usual in *Bulimulus*, though it seems to combine some of the characters of that and of the simply ribbed form of jaw.

Lingual membrane as in *B. chrysalis;* no side cutting points to centrals and inner laterals. (Pl. XI, fig. J.)

Leptomerus corneus. Nicaragua. Mr. McNiel.

Jaw as in *Bulimulus;* 15 ribs.

Lingual membrane as in *B. chrysalis.*

Rhinus durus, Spix. Brazil. J. G. Anthony.

Jaw as usual in *Bulimulus.*

Lingual membrane as in *B. chrysalis.*

Plectostylus Peruvianus. Brug. Talcahuana, Peru.

Jaw as usual in *Bulimulus;* 30 ribs.

Lingual membrane (Pl. XII, fig. J) combining the characters of that of *B. membranaceus* in the marginals with those of *B. chrysalis* in the centrals and the five laterals on both sides of the median line; the cusp of the last is large, oblique, rounded.

Bulimulus Edwardsi, Mor. Lake Titicaca. Prof. Alex. Agassiz.

Jaw low, arcuate, ends rapidly acuminated, blunt; anterior surface with over ten distant ribs, some of the usual *Helix* type, others like the delicate ribs common in *Cylindrella*, *Bulimulus*, *Gœotis*. *Amphibulima*, etc.

Lingual membrane (Pl. XI, fig. K) with 44-1-44 teeth. Centrals of the usual *Helicinæ* type, tricuspid; laterals like centrals, asymmetrical, and consequently bicuspid. The change to marginals very gradual, and formed by the simple modification of the laterals. without any splitting of the inner cutting point.

Subgeneric position of this species is unknown to me, as of the following.

Bulimulus Gabbianus, Angas. Costa Rica. Dr. W. M. Gabb; formerly referred to *B. Irazuensis.*

Jaw as in *Bul. limnœoides*, but median ribs oblique; there are about 32 ribs.

Lingual membrane with marginals as in *B. Bahamensis.* (Pl. XII, fig. L.)

Cylindrella.

Jaw arched, ends attenuated; very thin, transparent; distant, delicate, oblique ribs, serrating either margin, those of the upper centre meeting or ending before reaching the lower margin.

Lingual dentition quite peculiar. As Messrs. Crosse and Fischer, in their exhaustive paper (Journ. de Conch., XVIII, Jan., 1870), have indicated the different types of dentition found in the genus, I have referred to their respective groups the various species I have examined.

Group A.—Two lateral teeth on each side of the median line; marginals of a different form, varying in number.

Cylindrella (*Casta*) *Chemnitziana*, Fér. Jamaica.

There are 10-1-10 teeth; two laterals on each side.

Cylindrella cyclostoma, Pfr. (*Trachella.*) Lomas de Camoa, Cuba. Mr. Arango.

Jaw with over 70 ribs.

Lingual membrane with 10-1-10 teeth, two being laterals on either side; the first marginal is a modification of the laterals, other marginals of usual long and narrow shape, upper margin reflected.

Cylindrella Humboldtiana, Pfr. Cuba. Mr. Arango.

Jaw with over 100 ribs.

Lingual membrane with 8-1-8 teeth, as in *C. rosea*, figured by Crosse and Fischer. The species belongs to their group *Thaumasia*.

Cylindrella rosea, Pfr. (*Urocoptis.*)

Jaw photographed in Am. Journ. Conch., V, p. 37.

Cylindrella subula, Fér. (*Mychostoma.*) Jamaica. Mr. H. Vendreyes.

Lingual membrane with 10-1-10 teeth, as in *C. gracilis*, figured by Crosse and Fischer. Lower margin of base of attachment of laterals delicately fringed or crimped; marginals 8, long, laminar, with irregularly recurved apices.

Cylindrella seminuda, Ad. (*Mychostoma.*) Jamaica. Mr. Gloyne.

Lingual membrane as in last species.

Group C.—Lateral teeth more than two: marginal teeth similar to, and not to be distinguished from, the laterals.

Cylindrella elegans, Pfr. (*Gongylostoma.*) Cuba. Mr. Arango.

Lingual membrane (Pl. XIV, fig. B) with 12-1-12 teeth arranged *en chevron*; centrals long, narrow, apex recurved with three short, bluntly trilobed cusps and large cutting point; laterals with one inner, widely expanding, oval, inner cutting point, surmounted by a blunt narrow pedicle, and one much smaller cutting point on a narrow, high pedicle; there are no distinct marginals, the teeth becoming much modified in shape as they pass off laterally.

Cylindrella ornata, Gundl. (*Gongylostoma*). Cuba. A dried specimen in Mr. Bland's collection.

Lingual membrane (Pl. XIV, fig. A) with 18-1-18 teeth; as in last species.

Cylindrella Poeyana, D'Orb.

See Terr. Moll., V.

Macroceramus.

Jaw as in *Cylindrella.*

Lingual membrane, See Terr. Moll. V.

Macroceramus Gossei, Pfr. See Terr. Moll., V.

Macroceramus turricula, Pfr. Lomas de Camoa, Cuba. Mr. Arango.

Jaw with 35 ribs.

Lingual membrane as in last species (Pl. XIV., fig. D).

Macroceramus inermis, Gundl. Curaçao. Mr. J. S. Gibbons.

Lingual membrane as in *M. Gossei.*

Pineria.

Pineria Viequensis, Pfr. Island of St. Martin. Dr. van Rijgersma.

Jaw with about 28 ribs as in *Cylindrella* (Pl. XV, fig. B); upper median portion of the jaw figured is imperfect.

Lingual membrane (Pl. XIV, fig. C) as in group A of *Cylindrella*; laterals two; marginals five or six, long, narrow, simple, with irregularly recurved upper margins.

Partula.

Jaw as in *Cylindrella*. Pl. XV, fig. O, represents that of an undetermined species; there are over 60 ribs on that of *P. virginea*.

Lingual membrane broad; (that of *amanda* is figured on Pl. XI, fig. L) the central tooth is as common in the *Helicidæ*, with subobsolete side cusps, but side cutting points; the laterals are longer and broader than the central, with a side cusp and cutting point; the marginals have a long, narrow, quadrangular base of attachment, curving outward, extending beyond the reflection above; reflection small, with a highly developed cutting point, obliquely and bluntly tricuspid on its outer edge, the inner division the largest; the number of perfect laterals varies somewhat, 7 in *citrina*, 11 in *planilabrum*, 10 in *abbreviata* and *amanda*, 8 in *umbilicata*, *bilineata* and *virginea*; 5 in *gracilis*; there were 120 marginals in *virginea*; the number varies in the different species, but they are always numerous; the dentition of all examined by me agrees with the figure of that of *lirata* by Heynemann, Mal. Blatt., 1867, Pl. I, figs. 1—1a.

The species were determined by Mr. Garrett. I examined :—

P. fusca, Pease.
citrina, Pease.
planilabrum, Pease.
abbreviata, Pease.
umbilicata, Pease.
bilineata, Pease.
amanda, " (Pl. XI, fig. L)
virginea, Pease.
gracilis, Pease.
turgida, Pease.
rosea, Brod.
formosa, Pease.
lugubris, Pease.
varia, Brod.
compacta, Pease.
Garretti, Pease.
dentifera, Pease.
crassilabris, Pease.
Hebe, Pfr.
protea, Pease.
globosa, Pease.
approximata, Pease.
faba, Martyn.

ELASMOGNATHA.

Jaw with accessory plate to its upper margin.

Omalonyx.

Omalonyx felina, Guppy. Demarara. Mr. J. S. Gibbons.

Jaw with the accessory plate as usual in the genus.

Lingual membrane (Pl. XI, fig. M), centrals tricuspid ; laterals larger, but also tricuspid ; marginals irregularly pectinate.

Specimens from Trinidad have the same dentition.

Succinea.

For jaw and dentition, see Terr. Moll., V.

Succinea pallida, Pfr. Raiatea Island. Mr. A. Garrett.

Jaw as usual ; no anterior ribs.

Lingual membrane (Pl. X, fig. K) with about 30-1-30 teeth ; eleven laterals on either side.

Succinea papillata, Pfr.

Jaw as in last.

Lingual membrane (Pl. X, fig. L) with 25-1-25 teeth, nine laterals on each side ; some of the outer laterals have their outer cutting point bifid.

Succinea sagra, D'Orb. Jamaica

Jaw as usual; a median projection to cutting edge.

Lingual membrane as usual in the genus.

Succinea canella, Gld. West Maui, Sandwich Islands.

Jaw and lingual membrane as usual.

Succinea Barbadensis, Guild. Barbadoes.

As in last species.

GONIOGNATHA.

Jaw in separate pieces : the upper median one usually triangular.

Orthalicus.

For jaw and lingual membrane, see Terr. Moll., V.

Orthalicus obductus, Shuttl. Islands in the Bay of Panama. Mr. McNiel.

Jaw as usual in the genus.

Lingual membrane (Pl. XII, fig. B) as usual in the genus, with lateral teeth; teeth about 96-1-96. The base of attachment in centrals and first marginals is extended beyond the reflection.

Orthalicus gallina-sultana, Chemn. Marañon, Peru. Prof. Orton.

Jaw with 15 plates (Pl. XV, fig. N).

Lingual membrane (Pl XII, fig. C) 13 mm. broad, 16 mm. long, The rows of teeth are arranged in a backward curve from the median line for a short distance, and then run obliquely to the outer margin of the membrane; marginals as usual in the genus, but the central tooth differs in having a long, stout, lance-like cutting point, bearing at the middle of each slde a prominent, subobsolete, blunt spur ; three laterals on either side like the central, but asymmetrical, with the spur only on their outer sides ; teeth in one row 108-1-108.

Liguus.

For jaw and lingual membrane, see Terr. Moll., V.

Liguus virgineus. Linn. Aux Cayes, Haiti. R. Swift.

Lingual membrane (Pl. XII, fig. A).

The marginal teeth are as usual in the genus, but centrals and laterals differ; membrane 4½ x 18 mm.; teeth 40-1-40 ; the centrals and two first laterals have a short, stout, pointed cutting point, of the same type as described in *Orthalicus gallina-sultana.*

This completes the list of terrestrial Pulmonata* examined by me ; the following have also been described from other orders, generally with a figure.

PULMONATA LIMNOPHILA.

Melampus bidentatus, Say. Ann. Lyc. N. H. of N. Y., IX, 286.

Alexia myosotis, Dr. L. & Fr. W. Sh. N. A., II, 1.

Carychium exiguum, Say. " " " 6.

Limnœa appressa, Say. Am. Journ. Conch., VII, 161; L. & Fr. W. Sh., II, 28.

stagnalis, L. L. & Fr. W. Sh., II, 155.

megasoma, Say. Am. Journ. Conch., VII, 162.

columella, Say. L. & Fr. W. Sh. N. A., II, 24.

catascopium, Say. " " " 55.

Pomphòlyx effusa, Lea. Am. Journ. Conch., VI, 312.

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* Excepting *Buliminus Natalensis*, unfortunately omitted. (See Ann. N. Y. Acad. Sci., I, 362, Pl. XV, fig. J.

Physa vinosa, Gld. L. & Fr. W. Sh. N. A., II, 81.
ancillaria, Say. " " " 83.
Physa ———. Ann. Lyc., IX, 255.
Planorbis trivolvis, Say. Ann. Lyc., IX, 292.
Ancylus Newberryi, Lea. L. & Fr. W. Sh. N. A., II, 22.
Erinna Newcombi. A. Ad. Ann. Lyc., X, 349; Phila. Proc., 1874, 54.
Gundlachia Californica, Rowell. L. & Fr. W. Sh. N. A., II, 148.

PECTINIBRANCHIATA.

Geomelania. Am. Journ. Conch., VII, 185.
Blandiella reclusa, Guppy. " " "
Megalomastoma bituberculatum, Sowb. Am. Journ. Conch., VI, 213.
Tulotoma magnificum, Conrad. Ann. Lyc., IX, 293.
Pomus depressa, Say. L. & Fr. W, Sh., III, 1.
Vivipara intertexta, Say. " " 16.
Melantho integra, Say. " " 35.

SCUTIBRANCHIATA.

Neritella reclivata, Say. L. & Fr. W. Sh., III. 101.
Stoastoma pisum, Ad. Am. Journ. Conch., VII, 184.
Helicina occulta, Say. Ann. Lyc., IX, 287; Am. Journ. Conch., VII, 29.
———. L. & Fr. W. Sh., III, 116.
orbiculata, Say. Am. Journ. Conch., VI, 214.

Description of Plates.

PLATE II.

Lingual Dentition of

Fig. A. Nanina subcircula, Mouss.
B implicata, Nevill.
C argentea, Rve.
D Rawsonis, Barclay.
E Calias, Bens.
F Calias, Bens. Abnormal central tooth.
G. Limax semitectus, Mörch.
H. Velifera Gabbi, W. G. Binn.
I. Macrocyclis euspira, Pfr.

J. Leucochroa Boissieri, Charp.
K. Sagda Haldemaniana, Ad.
L. Patula Huahinensis, Pfr.
M. Endodonta tumuloides, Garrett.
N. " incerta, Mouss.
O. Acavus Phœnix, Pfr.

PLATE III.

Lingual Dentition of

Fig. A. Onchidium Schrammi, Bl.
B. Veronicella —— (from Brazil).
C. Polymita muscarum, Lea.
D. " " (central magnified).
E. " picta, Born.
F. Tornatellina aperta, Pse.
G. Achatinella producta, Rve.
H. Geomalacus maculosus, Allm.
I. Pella rariplicata, Bens.

PLATE IV.

Lingual Dentition of

Fig. A. Hemitrochus Troscheli, Pfr.
B. " gallopavonis, Val.
C. " rufoapicata, Poey.
D. " Milleri, Pfr.
E. " graminicola, Ad.
F. Caracolus excellens, Pfr.
G. " Sagemon, Beck, Cuba.
H. " " " Gonave Is. Haiti.
I. " Arangiana, Poey.
J. " marginella, Gmel.

PLATE V.

Lingual Dentition of

Fig. A. Cysticopsis tumida, Pfr.
B. " pemphigodes, Pfr.
C. Plagioptycha loxodon, Pfr,
D. " Albersiana, Pfr.
E. " monodonta, Lea.
F. " Duclosiana, Fér.
G. " diaphana, Lam.
H. " macroglossa, Pfr.
I. Leptoloma fuscocincta, Ad.

J. Coryda Gossei, Pfr.
K. Plebicula lurida, Lowe.
L. Helix,—Ann. N. Y. Ac. Sc., I, 261 (see p. 113).

PLATE VI.

Lingual Dentition of

Fig. A. Newcombia venusta, Mighels.
B. Laminella picta, Mighels.
C. " obesa, Newc.
D. " decorticata, Gul.
E. " Mastersi, Newc.
F. " luctuosa, Pfr.
G. Leptachatina textilis, Fér.
H. " nitida, Newc.
I. Carelia bicolor, Jay.
J. Fruticicola pubescens, Pfr.
K. Dorcasia pyrozona, Phil.
L. " similaris, Fér.
M. " globulus, Müll.
N. Turricula tuberculosa, Conr.

PLATE VII.

Lingual Dentition of

Fig. A. Strophia decumana, Fér.
B. " mumia, Brug.
C. " iostoma, Pfr.
D. Stenogyra hasta, Pfr.
E. Cionella Gloynei, Gibbons.
F. Cæcilianella Gundlachi, Pfr.
G. Lithotis rupicola, Blandf.
H. Clausilia tridens, Chemn.
I. Anadenus, ———.
J. Simpulopsis corrugatus, Guppy.
K. Cryptostrakon Gabbi, W. G. B.
L. Microphysa circumfirmata, Redf.

PLATE VIII.

Lingual Dentition of

Fig. A. Pomatia Humboldtiana, Val.
B. " Sieboldtiana, Phil.
C. Leptaxis undata, Lowe.

D. Thelidomus discolor, Fér.
E. " aspera, Fér.
F. " auricoma, Fér.
G. " notabilis, Shuttl.
H. " Jamaicensis, Chemn.
I. " provisoria, Pfr.
J. Eurycratera angulata, Fér.
K. " crispata, Fér.
L. Polydontes Luquillensis, Shuttl.
M. Stylodon Studeriana, Fér.
N. Tebennophorus Costaricensis, Mörch ?

PLATE IX.

Lingual Dentition of

Fig. A. Dentellaria orbiculata, Fér.
B. " Isabellæ, Fér.
C. " dentiens, Fér.
D. " nucleola, Rang.
E. " nuxdenticulata, Chemn.
F. " pachygastra, Gr.
G. " badia, Fér.
H. " formosa, Fér.
I. " Josephinæ, Fér.
J. " perplexa, Fér.
K. " lychnuchus, Müll.

PLATE X.

Lingual Dentition of

Fig. A. Pleurodonta acuta, Lam.
B. " Carmelita, Fér.
C. " Schroeteriana, Pfr.
D. " invalida, Ad.
E. Merope fringilla, Pfr.
F. Helix astur, Souv.
G. " convicta, Cox.
H. Macrodontes odontostomus, Sowb.
I. Pelecychilus auris-Sileni, Born.
J. " glaber, Gmel.
K. Succinea pallida, Pfr.
L. " papillata, Pfr.

PLATE XI.

LINGUAL DENTITION OF

Fig. A. Anthinus multicolor, Rang.
B. Pachyotus egregius, Jay.
C. Orphnus foveolatus, Rve.
D. " Hanleyi, Pfr.
E. Dryptus marmoratus, Dunker.
F. Eurytus aulacostylus, Pfr.
G. Canistrum fulgetrum, Brod.
H, I. Gæotis, —— ———.
J. Leptomerus sepulcralis, Poey.
K. Bulimulus Edwardsi, Mor.
L. Partula amanda.
M. Omalonyx felina, Guppy.

PLATE XII.

LINGUAL DENTITION OF

Fig. A. Liguus virgineus, Lin.
B. Orthalicus obductus, Shuttl.
C. " gallina-sultana, Chemn.
D. Scutalus rhodolarynx, Rve.
E. Leptomerus limnæoides, Fér.
F. Drymæus Bahamensis, Pfr.
G. Mesembrinus primularis, Rve.
H. Thaumastus immaculatus, Ad.
I. Mormus laticinctus, Guppy.
J. Plectostylus Peruvianus, Brug.
L. Bulimulus Irazuensis, Ad.

PLATE XIII.

LINGUAL DENTITION OF

Fig. A. Amphibulima patula, Brug. St. Kitts.
B. " " " "
C. " " " Dominica.
D. " " " "
E. " appendiculata, Pfr.
F. " rubescens, Desh.
G, H. " Rawsonis, Bl.

PLATE XIV.

Lingual Dentition of

Fig. A. Cylindrella ornata, Gundl.
B. " elegans, Pfr.
C. Pineria Viequensis, Pfr.
D. Macroceramus turricula, Pfr.
E. Drymæus Lobbi, Rve.
F. " altoperuvianus, Rve.
G. Mesembrinus chrysalis, Pfr.

PLATE XV.

Jaw of

Fig. A. Gæotis.
B. Pineria Viequensis, Pfr.
C. Microphysa turbiniformis, Pfr.
D. Amphibulima rubescens, Desh.
E. " patula, Brug.
F. " appendiculata, Pfr.
G. Pella rariplicata, Benson.
H. Fruticicola pubescens, Pfr.
I. Stenogyra hasta, Pfr.
J. Clausilia tridens, Pfr.
K. Polymita muscarum, Lea.
L. Limax semitectus, Morch ?
M. Caracolus Arangiana, Poey.
N. Orthalicus gallina-sultana, Chem.
O. Partula.
P. Bulimulus (Drymæus) Lobbi, Rve.
Q. " (Mesembrinus) chrysalis, Pfr.

PLATE XVI.

Jaw of

Fig. A. Cysticopsis tumida, Pfr.
B. Helix astur, Souv.
C. Lithotis rupicola, Blandf.
D. Carelia bicolor, Jay.
E. Achatinella (Laminella) Mastersi, Newc.
F, G. Cæcilianella Gundlachi, Pfr.
H. Pomatia Sieboldtiana, Phil.
I. Bulimulus (Leptomerus) limnæoides, Fér.
J. Hemitrochus Milleri, Pfr.

K. Urocyclus Kirki, Gray.
L. Cryptostrakon Gabbi, W. G. Binn.
M. Achatinella (Newcombia) picta, Mighels.
N. Dentellaria dentiens, Pfr.
O. " nucleola, Rang.
P. " pachygastra, Gr.
Q. " badia, Fér.
R. " formosa, Fér.
S. " Josephinæ, Fér.
T. " perplexa, Fér.
U. " lychnuchus, Müll.
V. " nuxdenticulata, Fér.
W. " orbiculata, Fér.

PLATE XVII.

Lingual Dentition of

Fig. A. Chlamydephorus Gibbonsi, W. G. B.
B. Glandina rosea, Fér.
C. " semitarum, Rang.
D. " Phillipsi, Ad.
E. " aurata, Mor.
F. Gonospira palanga, Fér.
G. " Newtoni, H. Ad.
H. " Mauritiana, Mor.
I. " Nevilli, H. Ad.
J. Ennea clavatula, Lam.
K. Spiraxis Dunkeri, Pfr.
L. Rhytida vernicosa, Kraus.
M. Stenopus decoloratus.
N. Urocyclus Kirki, Gr.
O. Nanina Chamoissi, Pfr.
P. " radians, Pfr.
Q. Trochomorpha Cressida, Gld.

IV.—*The Literature of Ozone and Peroxide of Hydrogen. Second Memoir, including:*

I. HISTORICAL-CRITICAL RESUMÉ OF THE PROGRESS OF DISCOVERY SINCE 1879.

II. INDEX TO THE LITERATURE OF OZONE, (1879–1883).

III. INDEX TO THE LITERATURE OF PEROXIDE OF HYDROGEN, (1879–1883).

BY ALBERT R. LEEDS.

Read December 17th, 1883.

PREFACE.

At the meeting of the Chemical Section of the N. Y. Academy of Sciences, held June 12th, 1880, I had the pleasure of presenting to the Academy a first Memoir upon "The Literature of Ozone and Peroxide of Hydrogen." This memoir consisted of four parts. 1st, A historical and critical essay upon the "Lines of Discovery in the History of Ozone," from the first observation of Schönbein in the year 1840, to the facts made known in the earlier portion of the year 1879. This prefatory essay discussed under separate sections, the original discovery of ozone, its sources and its properties:—also, the nature of the constituent matter of ozone:—finally, the exact nature of the relations existing between ozone and ordinary oxygen.

The second part of the memoir was an "Index to the Literature of Ozone (1785-1879). This memoir was drawn up on the plan suggested by my friend and predecessor as Corresponding Secretary of the Academy, Dr. H. Carrington Bolton. Dr. Bolton had been led, during the course of his classic investigations upon the Fluorides of Uranium (Berl. Akad. Ber., 1866, 299), to prepare for his own more exact knowledge, a partial index to the literature of uranium. In the hope of saving future investigators from the great labor of repeating his work, Dr. Bolton completed this Index, and published it in the Annals of the N. Y. Academy of Sciences, or as the society was then called, the N. Y. Lyceum of Natural History, Vol. IX, February, 1870. This first publication was followed by a second (idem, XI, Nov., 1875), in which Dr. Bolton has given in the compass of 44 finely printed octavo pages, an "Index to the Literature of Manganese," beginning as far back as the year 1596, and brought down through nearly three centuries, to the year 1874.

His labors prompted Prof. E. J. Hallock to continue the work by preparing an "Index to the Literature of Titanium," (1783-1876,) published in Ann. N. Y. Acad. Sci., Vol. I, p. 53, Dec. 1876, and Prof. G. J. Rockwell, a similar "Index to the Literature of Vanadium" (1801-1876), idem, Vol. I, p. 133. Since the publication of the two indices by the author, the Academy has also published an "Index to the Literature of Electrolysis," idem, Vol. II, p. 313, by Mr. W. W. Webb.

The third portion of the author's preceding memoir was an essay upon "The History of Antozone and Peroxide of Hydrogen." It pointed out the fallacy of the arguments and proofs offered by Schönbein and Meissner, for the existence of the so-called Antozone, and described the experiments of Von Babo, Nasse, Engler, and others, by which the certainty of the non-existence of Antozone had been demonstrated. The essay furthermore gave some account of the artificial sources of Peroxide of Hydrogen, and of the experiments devoted to a demonstration of its probable occurrence in nature. This was followed by a fourth part, devoted to an "Index to the Literature of Peroxide of Hydrogen" (1818-1878), similar in plan to that upon ozone.

In returning to this subject, it is with the hope of assisting fellow-students in two ways. First, by bringing these indices down to date, which will make the preceding work of much greater utility. Secondly, by pointing out the uselessness of repeating, as is being constantly done, the investigation of matters previously studied with thoroughness, and of overlooking other topics which are at present incompletely understood.

I. Sources and Preparation of Ozone.

The formation of ozone is to be looked for in all cases where the molecule of oxygen undergoes decomposition under conditions which render it possible for the constituent atoms to exist in a free or uncombined condition for an interval of time. This setting free of the constituent atoms of the molecule is what was known in the older chemistry as the nascent state of the element in question. And whilst the increased energy of chemical properties possessed by the element, at the instant of being liberated from a previous chemical combination, or in *statu nascenti*, was a fact of universally recognized importance, yet a satisfactory explanation of this increase of energy was not possible until the distinction between the chemical atom and the chemical molecule was established as a fundamental fact of the newer chemistry. Ordinarily, the nascent atom immediately enters into combination again, either with an atom of the same kind, as for instance an atom of hydrogen with an atom of hydrogen to form a molecule of hydrogen in all respects similar in its properties to ordinary hydrogen gas, or with an atom of a different kind to form a different substance. In the case of oxygen, however, these free atoms may not only reunite by twos to form the ordinary dual molecule, known as oxygen gas, but by threes to form the triple molecule, which is ozone.

According to the older chemistry, it would have been difficult to assign a reason why free hydrogen atoms might not reunite to form a triple molecule of hydrogen, just as well as free oxygen atoms. And as a matter of history, Osann endeavored to prove that the hydrogen given off in electrolysis differs from ordinary hydrogen, just as the oxygen given off differs from ordinary oxygen. He ascribed to such electrolytic hydrogen a weak acid smell, and the power of readily reducing silver and other metallic salts, and distinguished it by the name of ozone-hydrogen. But these properties were in reality due to other bodies in the electrolytic hydrogen, to say nothing of the fact that absolutely pure hydrogen gas has the power of slowly reducing silver from its salts.

It is not in accordance with our present knowledge concerning hydrogen, to regard the existence of such a body as Osann's supposed ozone-hydrogen as possible. For in all its known chemical combinations, hydrogen possesses but one bond of chemical attraction, and a molecule of hydrogen possessing three or more hydrogen atoms would lack the bonds to hold it together. Chlorine, on the other hand, has one, three, five, or seven bonds, according to the nature of the element with which it is brought into combination, and whilst it is certain that we do not understand the true meaning of this varying number of bonds, yet there is no reason why a number of allotropic modifications of chlorine might not exist, with different densities, color, chemical properties, etc. So is it likewise with phosphorus, arsenic, nitrogen, and other polyvalent elements. The allotropism of phosphorus, for example, may be due to one of three causes : a difference in the amounts of internal energy, a difference in the relative positions of the constituent atoms, or a difference in the number of these atoms. The first supposition we need not entertain, because it would carry with it the admission that the differences between the substance-matter of all the elements themselves, consists in differences in the quantity and kind of their internal energy. This admission chemists are not prepared to make. The last supposition includes the second, and explains the most important difference in the properties of the allotropic modifications of an element, their specific gravities. Moreover it is in harmony with the only case of allotropism, in which we are enabled to compare the allotropes in the gaseous condition, and it is in the gaseous condition that the relative number of atoms in a molecule may be best compared. The specific gravity of ozone is to that of oxygen as 3 to 2, which is in harmony with the supposition, the most probable one on many other grounds as well, that the molecule of ozone consists of three, the molecule of oxygen of two atoms of oxygen.

The difference between the ordinary translucent modification of phosphorus and the red, may be explained by supposing the molecule of the former to contain 7 atoms, that of the latter 8. In this case the weights of the molecules would be as 217 to 248, or as 1.83 to 2.1, which latter numbers represent the actual specific gravities. Similarly, if we suppose the molecule of crystallized metallic phosphorus, the third allotropic modification, to consist of 9 atoms, its molecular weight in the solid condition would be to the molecular weight of ordinary phosphorus as $279 : 217 = 2.35 : 1.83$, which latter numbers represent the actual specific gravities as determined by experiment.

Nitrogen was announced by Mr. Stillingfleet Johnson, in two papers read before the English Chemical Society in 1880, to be capable of existing in two allotropic modifications, his announcement being based on an experiment in which a certain kind of nitrogen, that obtained by the decomposition of ammonium nitrite, had been made to enter into direct union with hydrogen to form ammonia, while another kind of nitrogen, that existing in atmospheric air, would not so combine. But Mr. H. B. Baker has very recently shown (Chem. News, XLVIII, 187, 279), that Mr. Johnson's results were erroneous, the mixed gases containing oxides of nitrogen, which gave rise to ammonia under the conditions of the experiment; and the existence of a new allotrope of nitrogen is still under discussion.

To return from this consideration of allotropism in general, and examine the thesis at the beginning of the section :—The formation of ozone is to be looked for in all cases where the molecule of oxygen undergoes decomposition under conditions which render it possible for the constituent atoms to exist in a free or uncombined condition for an interval of time.

This setting free of the component atoms of the molecule (*status nascens*), always precedes the formation of ozone, inasmuch as before a combination of atoms by threes can occur, a decomposition of the preceding combinations by twos, must take place. This, it will be urged, is a self-evident proposition, and I am very glad to admit that it is. But I am not the less impressed with the importance of distinctly formulating it in this place, because in much of the writing upon this topic it is ignored, and also because in many places this oxygen of the nascent state (free atoms), is called active oxygen and is frequently confused with ozone itself. This confusion is so probable (since ozone is most certainly the active allotrope of oxygen), that it appears to me inexpedient to speak of nascent oxygen, as active oxygen, and of the process of making it, as the activation of oxygen. To guard against this danger, I shall term the process the *atomation* of oxygen, and the freed atoms themselves, not active, but *atomic* oxygen. But, it may be asked, what experimental proof is there that atomic oxygen precedes in every instance, the formation of ozone ? The answer is to be found in the fact that ozone is incapable of producing certain chemical changes, readily producible by atomic oxygen ; whilst, on the other hand, atomic oxygen, under the conditions referred to, can produce not only these chemical changes, but at the same time, and by a similar action, ozone itself.

The proof of this statement is set forth in a paper which the author published in the Journal of the American Chemical Society for 1879, p. 232, and subsequently in the Proceedings of the German Chemical Society.

It was there shown that carbon monoxide would undergo conversion into carbon dioxide, under the same circumstances as would bring about the conversion of ordinary oxygen into ozone: that is to say, when a mixture of carbon monoxide and air was subjected to the action of moist phosphorus. Later in the same year, I was induced by the theoretic importance of the subject, to study it anew, and to endeavor to learn whether the production of the carbon dioxide in this experiment was due to the action of ozone, or whether it was due to the production in the first place of atomic oxygen, and the subsequent combination of this atomic oxygen on the one hand with carbon monoxide to form carbon dioxide, and on the other hand with oxygen to form ozone.

Whether in chemical language, the action was:

$$(1)\ O_3 + CO = CO_2 + O_2$$

or, as a first step,

$$(2)\ O_2 = O + O$$

and then, as second steps occurring simultaneously,

$$(3)\ O + CO = CO_2,\ \text{and}\ O + O_2 = O_3$$

In this second series of experiments (ibid., p. 450) I employed oxygen ozonized by the ozonizing battery to the extent of 72 mgrms. of ozone per liter, while in the earlier experiments the percentage did not exceed 5 mgrms. per liter. But no production of carbon dioxide took place, however long the carbon monoxide and ozone remained in contact. Furthermore, when carbon monoxide and oxygen were separately submitted to the electric effluve, and then brought together, no carbon dioxide was formed. But when the two gases were first brought together in suitable proportion, and then the mixture submitted to the electric effluve, carbon dioxide was produced in quantities readily admitting of quantitative measurement.

I regarded this experiment as demonstrating the existence of atomic oxygen as prior to, and necessary to, the production of both carbon dioxide and ozone. In other words, that equations (2) and (3) represented the true sequence and coördination of the phenomena, and not equation (1).

Three years subsequently, Baumann repeated this experiment (Ber. der deutsch. Chem. Gesell., XIV, 2706), and obtained the same result. These results having been questioned by Remsen and Keiser (Amer. Chem. Jour., IV, 454) on the ground of their having obtained a negative result, I repeated my original experiment with air and carbon monoxide over moist phosphorus, every source of error being rigorously guarded against, and obtained even larger amounts of carbon dioxide than in my earlier investigation,—in one case 15.5 mgrm. Since that time, Baumann has likewise repeated the experiment, and obtained in one trial, 23.3 mgrm. carbon dioxide, in another case 64.6 mgrms.

The atomation of oxygen, and the setting free of atomic oxygen, as a step necessarily antecedent to the formation of ozone, has therefore, I conclude, been established by rigorous experimental proof. In the case of the electric effluve, the intervening oxygen dielectric undergoes polarization, and a certain number of its molecules are decomposed into atoms. Certain of these atoms recombine among themselves, or combine with the oxygen molecules, to form ozone, the amount of the ozone produced depending upon the strength of the electric effluve, upon the duration of electrification, the temperature, presence of foreign gases or vapors admixed with the gaseous electrolyte, and the other conditions of the experiments.

If the atomation of the oxygen be brought about by the reduction of the oxygen molecule by means of phosphorus, partly covered by water, there will be formed by the atomic oxygen thus produced, ozone, hydrogen peroxide, and ammonium nitrate. If ammonium nitrite is produced, as an intermediary step, it is not found in the final products. These three substances, as I have always insisted since the publication of the investigation upon which the statement is based (Jour. Amer. Chem. Soc., 1879, Vol. I, 150), are three necessarily associated bodies, all secondary in their genesis, and dependent upon the previous formation of atomic oxygen. The reaction takes place, primarily, according to the equations :—

$$(1)\ P_2 + 2O_2 = P_2O_3 + O \text{ and } P_2 + 3O_2 = P_2O_5 + O$$

and secondarily, according to the equation

$$O, O, O + O_2 + NN + 3H_2O = O_3 + H_2O_2 + NH_4NO_3 \text{ *}$$

The ozone passes off in the atmosphere. The hydrogen peroxide and the ammonium nitrate mostly remain behind in the jar-water, though certain amounts can be detected in the wash-waters, if any such be employed to wash the escaping ozone. The white cloud above the wet phosphorus is mainly hydrogen peroxide associated in a state of vesicular suspension with aqueous vapor, and constitutes the antozone cloud of Schönbein (the atmizone of Meissner).

In all these cases, besides the production of atomic oxygen as a necessary antecedent, its formation at temperatures consistent with the possible formation of ozone, hydrogen peroxide, etc., must be predicated. And inasmuch as ozone is slowly converted even at the boiling point of water into oxygen (at once at a temperature of 237° C.), the importance of maintaining a low temperature is manifest. When the atomation of oxygen is brought about by moist phosphorus, no action occurs below 6° C. At 24° the formation of ozone is at a maximum, the production falling off very rapidly, as the temperature rises above this point. When atomic oxygen is set free in the electrolysis of acidulated water, the gas evolved at the positive electrode contains, according to Soret, 1 p. c. of ozone, when the temperature of the electrolyte is maintained at 6° C., and 2 p. c. when at 0°.

But whilst the lower temperatures spoken of are those most favorable to the permanence of the products of the action of atomic oxygen, yet the evidence is very strong that even under circumstances apparently unfavorable and at high temperatures, the atomic oxygen may bring about the formation of ozone, hydrogen peroxide and ammonium nitrite. It was stated by Loew

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* In an article upon the "Preparation of Phosphoric Acid by the oxidation of Phosphorus with Air in presence of Moisture," (Pharm. J. Trans. [3], XIV, 24-26, and Jour. Chem. Soc., December, 1883, p. 1050), W. T. Wenzell has obtained the same results, and has adopted in their explanation the hypothesis here stated.

(Chem. News, XXI, p. 107,) that ozone is formed when air is blown through a gas-flame under proper conditions. This was denied by Böttger (Chem. Centr., 1870, 161), who stated that ammonium carbonate and hydrogen peroxide are formed under these conditions. During the same year (1870), Than brought forward certain experiments to show that ozone was formed during the rapid combustion of all hydrogenous bodies. (J. pr. Chem. [2], I, 415.) The year following, Pincus confirmed Than's statement (Pogg., Ann., CXLIV, 480), and Struve published his research to show that ozone, hydrogen peroxide and ammonium nitrite, all three were formed in the combustion of hydrogen (Bull. de l'Acad. Imp. des Sci. de St. Petersbourg, XV, No. 3). By experiments conducted with extreme care, Zoeller and Grete (Berl. Berichte, X, 2144), showed that in the burning of pure hydrogen in pure air, ammonium nitrite is formed in very notable quantities. Much later Böttger (Chem. Centr., 1878, p. 574) found that hydrogen peroxide is formed on the explosion of a mixture of pure oxygen and hydrogen. Inasmuch, however, as certain very careful observers, like Zoeller and Grete, have demonstrated the formation of one only of the three products, it is necessary that a more complete demonstration of the production of all three bodies in rapid combustion be brought forward, before it can be regarded as finally established.

The subject of the atomation of oxygen was studied at great length by Schönbein, and a large number of important facts noted by him. But at that time the true nature of ozone was not known. According to Schönbein, ozone itself was one kind of atomic oxygen, namely, the free atom in an electro-positive condition, and antozone another kind of atomic oxygen, the free atom in an electro-negative condition. He supposed that it was the latter kind which, in contact with water, generated hydrogen peroxide. Although ozone is certainly not what Schönbein supposed it to be, yet the existence of atomic oxygen as something necessarily preceding the formation of ozone may now be regarded as a demonstrated fact. And whilst it has not been shown that the free oxygen atoms may exist in two electro-negative conditions, yet such an hypothesis is theoretically not untenable, nor has it been demonstrated to be false.

Latterly, the number of cases in which the formation of active oxygen has been noted has been largely increased. Thus Hoppe-Seyler has pointed out that is formed when palladium-hydrogen is shaken up in contact with water and air (Berl. Berichte, XII, 1551). Under these circumstances he noted the formation of the third by-product, ammonium nitrite, as well. The author, prompted by theoretical considerations, sought for the presence of ozone and hydrogen peroxide, since according to the hypothesis above enunciated, both should be present. Ozone he failed to detect, hydrogen peroxide was found in quantity large enough to admit of its quantitative estimation (Berl. Berichte, XIV, 976). So also, palladium, platinum, and other so-called "carriers of oxygen," owe the energetic oxidizing actions which occur in their presence, and which were formerly spoken of as "catalytic," to their power of effecting a separation of the oxygen molecule into its constituent atoms. This is shown by the experiments of Traube and Baumann, who found that palladium will cause the oxidation of carbon monoxide to dioxide in presence of hydrogen peroxide, whilst without palladium no such oxidation occurs. It has been likewise noted by the author that platinum black, when shaken up in a bottle partly filled with air along with a solution of indigo, turns the latter yellow by causing its oxidation and the formation of isatin. Since this very powerful oxidizing action is not produced by oxygen in its ordinary condition, it may be ascribed to the atomation of the oxygen under the influence of the platinum black.

The number of observed cases of the formation of atomic oxygen has been largely increased by the recent researches of Radziszewski on the Phosphorescence of Organic Bodies. He divides such phosphorescent organic bodies into two groups: 1st. Those which phosphoresce when the atomic oxygen which they already contain, and which has been previously formed under the influence of some activating agent like sunlight, operates upon the organic body, on the addition of an alkali. 2d. Those bodies which, on the addition of an alkali, themselves form atomic oxygen, and by combining with this atomic oxygen, become phosphorescent. To the first group belong various hydrocarbons, especially the aromatic, the terpenes, etc. To the second, belong more especially the aldehydes, or such bodies as when treated with an alkali, form aldehydes. To the latter subdivision belong the fats of the series $C_n H_{2n-2} O_2$. Radziszewski explains in like manner the phosphorescence of organisms, since he finds in them a fat, together with an alkaline body. And in one of these, the *Pelagia noctiluca*, he thinks he has demonstrated the presence of atomic oxygen, by showing that the *Pelagia* develops a blue color when placed on porous plates moistened with potassium iodide, starch paste, and tincture of guaiacum.

II. Nature and Properties of Ozone and Hydrogen Peroxide.

The recent remarkable discoveries concerning the properties of ozone have strengthened the grounds on which the hypothesis of the nature of ozone stands. Recently, a lengthy series of memoirs has been written by Traube, in which he controverts both the present theory, as to the constitution of hydrogen peroxide, and the views now entertained of its action as an oxidizing agent. Hitherto, chemists have looked upon hydrogen peroxide as oxidized water, from the fact that it yields up one of its atoms of oxygen with great readiness, and therefore acts as an energetic oxidizing agent. In order that water may take up another atom of oxygen, a molecule of oxygen or an oxide must be decomposed, or an atom of atomic oxygen must enter into direct combination. Thus—

$$H—O—H + O = H—O—O—H.$$

Traube, on the other hand, has brought forward a number of experiments to show that peroxide of hydrogen is reduced oxygen; that is to say, the oxygen in the peroxide enters as a whole molecule, and as a molecule exists in combination with two atoms of hydrogen. But whilst Traube states the above as his hypothesis, and that both the atoms of oxygen are combined in the same manner, and with the same degree of chemical attraction, yet the structural formula which he gives is the same as the one ordinarily adopted; nor is the fact that one only of the oxygen atoms is readily parted with, explained by his theory any more satisfactorily than by the ordinary one. Moreover, the experiments, as detailed by Traube, are in opposition to the results many times obtained by the author in their repetition.

Without detailing these results in this place, it will suffice to state, that when zinc in fine division is shaken up with water and air, the oxygen of the air causes an energetic oxidation of the zinc. As a result of this oxidation, the oxygen molecule is divided, one atom going to the zinc and the other being for an instant set free. This atomic oxygen brings forth very energetic oxidations, oxidizing indigo to isatin, forming hydrogen peroxide, decomposing potassium iodide and developing nitrous acid. The latter speedily disappears, being oxidized by the peroxide of hydrogen to nitric acid, while the excess of peroxide of hydrogen, which appears to be the most abundant product of the reaction, is decomposed by the zinc.

It might be supposed that these phenomena are due to the oxidation of nascent hydrogen set free by the decomposition of the water itself. But this is not the case. Pure zinc does not decompose water, and ordinary zinc decomposes it in too small an amount to explain the observed phenomena. This being the case, zinc acts in a manner analogous to phosphorus, viz.:

$$Zn + H_2O + O_2 = ZnH_2O_2 + O$$

An experiment recently performed by Kappel can be best explained in like manner. On agitating Cu with an alkaline solution and air, he obtained the reaction both for ozone and hydrogen peroxide, but not the nitrous reaction. His test-papers suspended above the liquid became blue, but were immediately decolorised, a result attributed to the decomposition of the ozone first formed, by the peroxide of hydrogen. For on passing a current of air so as to remove the ozone, the hydrogen peroxide reaction was readily obtained. (Berl. Berichte, XV, 2359.)

III. Liquefaction and Color of Ozone.

The most important discoveries during the past three years concerning the properties of ozone, are those made by Hautefeuille and Chappuis. They found that ozone is a blue gas, the color appearing sky-blue even when only so much ozone is present as is obtained in the ozonation of the oxygen contained in a tube a metre in length, by the silent discharge. Furthermore, they found that under very great pressures the condensed gas becomes indigo blue. If the pressure is increased to 75 atmospheres and then suddenly relieved, a dense white cloud is formed, showing the beginning of liquefaction, whilst the same phenomenon does not take place with pure oxygen until a pressure of 300 atmospheres is attained. The ozone must be compressed slowly and with constant cooling, otherwise it will explode with evolution of heat and light. By mixing the ozone with carbon dioxide, and then submitting the mixture to great cold and pressure, Hautefeuille and Chappuis succeeded in obtaining a deep blue liquid, the blue color being due to the liquefied ozone.

The same observers have studied the absorption-spectrum of ozone, and accurate measurements of the same have been made by W. N. Hartley. The latter has extended the research to the absorption of certain parts of the sun's rays by atmospheric ozone. By this new optical method he has arrived at the conclusions—1st. That ozone is a constant constituent of the upper atmosphere. 2d. That it is present in larger amounts in the upper than in the lower part of the earth's atmosphere. 3d. That it is the cause of the blue color of the sky.

IV. Atmospheric Ozone.

In a former paper published in the Annals of the Academy, "Upon Ozone and the Atmosphere," I have detailed at length the experiments by which I sought to show that the so-called ozonoscopes, such as Schönbein's potassium iodide starch-papers, and Houzeau's potassium iodide and litmus papers, were of no value as tests for ozone *per se,* since they were equally affected by hydrogen peroxide, which is also present in the air. Schöne has arrived at the same results. But he has also shown that whilst even thallium papers are of no value as ozonoscopes, they are of value in the determination of atmospheric hydrogen-peroxide by exact chemical methods. Thus at the very time when the estimation of atmospheric ozone by any known chemical method had been found impossible, the researches of Hautefeuille, Chappuis and Hartley pointed out an entirely unlooked-for means of overcoming the difficulty. But as yet the practical utilisation of their discovery, and the influence of moisture, hydrogen peroxide, and other constituents of the atmosphere, in confusing or rendering difficult the observation of the ozone absorption-spectrum, have not yet been made known.

Hoboken, December 15, 1883.

SECOND INDEX

TO THE

LITERATURE OF OZONE.

Continued from p. 403, *Vol. I, Annals.*

1879	Hoppe-Seyler	Berl. Berichte, XII, 1551.	Activation of oxygen by nascent hydrogen.
	Leeds	J. Am. Chem. Soc., I, 450; Berl. Berichte, XII, 1836; Amer. Chem. J., I, 373.	Oxidation of carbon monoxide by air over moist phosphorus.
	"	J. Am. Chem. Soc., I, 442 et seq.	Non-production of Ozone from potassium dichromate and sulphuric acid. Non-production of Ozone from potassium permanganate and sulphuric acid. Production from barium peroxide and sulphuric acid. Production from hydrogen peroxide and sulphuric acid.
	Van Slouten	J. Am. Chem. Soc., I, 263.	Relative amounts of Ozone and organic impurities in the atmosphere.
	Wright	J. Chem. Soc., XXXVII, 422; Chem. News, XL, 169.	No Ozone, but nitrous acid, formed in combustion of coal gas.
1880	A. Volta	Gazz. Chim. Ital., IX, 521; Berl. Berichte, XIII, 203; Chem. News, XLI, 54; J. Chem. Soc., XXXVIII, 205.	Action upon certain noble metals.
	Leeds	Berl. Berichte, XIII, 568; J. Am. Chem. Soc., I, 145.	Upon ammonium nitrite and the secondary products obtained in the ozonation of air over moist phosphorus.
	McLeod	Berl. Berichte, XIII, 568; J. Chem. Soc., XXXVII, 118; Chemikerzeitung, 1880, 5; J. Am. Chem. Soc., II, 351.	Formation of Ozone by slow oxidation of phosphorus.
	Leeds	Berl. Berichte, XIII, 1066, 1132; J. Am. Chem. Soc., II, 34, 147; Chem. News, XLII, 17, 163.	Formation of hydrogen peroxide and Ozone by action of moist phosphorus upon air.
	"	Chem. News, XLI, 35.	Solubility in water.

1880	Kingzett	J. Chem. Soc., XXXVII, 792; Berl. Berichte, XIV, 248.	Atmospheric oxidation of phosphorus, and some reactions of Ozone and hydric peroxide.
	"	Chem. News, XLI, 182.	Peroxide of hydrogen and Ozone.
	Renard	Ann. de Chim. [5], XVI, 289, 337; J. Chem. Soc., XXXVIII, 24.	Action of Ozone obtained by electrolysis upon the alcohols.
	Kingzett	Chem. News, XLI, 76.	Note on the assumed formation of Ozone by the atmospheric oxidation of phosphorus.
	Schöne	Berl. Berichte, XIII, 1503, 2400; J. Chem. Soc., XXXIX, 20.	Proofs of the presence of Ozone in atmospheric air.
	Schöne	Berl. Berichte, XIII, 1508; J. Chem. Soc., XXXIX, 345.	Ozonometry with thallium papers.
	Hautefeuille and Chappuis	Compt. Rend., XCI, 228; Berl. Berichte, XIII, 1972; Chem. News, XLII, 119.	Influence of temperature and pressure upon the production of Ozone.
	"	Compt. Rend., XCI, 134; J. Chem. Soc., XXXIX, 221.	Absorption bands.
	"	Compt. Rend., XCI, 522; Berl. Berichte, XIII, 2230; Chem. News, XLII, 179; Chem. Centr., 1880, 754; J. Chem. Soc., XXXIX, 18.	Liquefaction of Ozone and its color in the gaseous state.
	Leeds	J. Am. Chem. Soc., II, 411; Berl. Berichte, XIII, 2351; Chem. News, XLII, 304; J. Chem. Soc., XXXIX, 221.	Preparation of Ozone by heating substances containing oxygen.
	Hautefeuille and Chappuis	Compt. Rend., XCI, 815; Berl. Berichte, XIII, 2408; Chem. News, XLII, 294; J. Chem. Soc., XXXIX, 786.	Liquefaction of Ozone in presence of carbon dioxide and its color in the liquid state.
	"	Compt. Rend., XCI, 762; Berl. Berichte, XIII, 2408; Chem. Centr., 1880, 787; Chem. News, XLII, 293.	Conversion of oxygen into Ozone by electricity in the presence of foreign gases.
	Mulvany	Chem. News, XLI, 292.	Ozone in nature, its relations, sources and influences.
	Ridout	Chem. News, XLI, 98; Pharm. J. Trans. [3], X, 727.	Production of Ozone during combustion of coal gas.
	Chappuis	Compt. Rend., XCI, 985; Berl. Berichte, XIV, 105; R. Soc. Proc., XXX, 152; Chem. News, XLIII, 36; J. Chem. Soc., XXXIX, 213; Amer. Chem. J., III, 153.	Absorption spectrum of Ozone.

1880	Potilitzin	Berl. Berichte, XIII, 2400.	KI ozonoscopes valueless on account of action of CO_2.
	Arnold	Rep. Anal. Chem., I, 226; Arch. Pharm. [3], XIX, 41.	Occurrence in milk (?).
	Berthelot	Compt. Rend., XC, 895; Bull. Soc. Chim. [2], XXXVI, 72.	Action upon ether with formation of ethyl peroxide.
1881	Hartley	J. Chem. Soc., XXXVIII, 111; R. Soc. Proc., XXXI, 51 and XXXII, 258; Chem. News, XLII, 268.	Absorption spectrum.
	Leeds	Berl. Berichte. XIV, 841; Chem. News, XLIII, 1881; J. Am. Chem. Soc., III, 5.	Formation of Ozone, H_2O_2 and NH_4NO_2 by ozonation of air with moist phosphorus.
	"	Berl. Berichte, XIV, 975; J. Am. Chem. Soc., III, 16.	Action of Ozone, H_2O_2 and nascent oxygen upon benzole.
	Chappuis	Berl. Berichte, XIV, 1014; Bull. Soc. Chim. [2], XXXV, 290; Am. Chem. J., III, 152.	Action upon the spores contained in air.
	Hautefeuille and Chappuis	Compt. Rend., XCII, 134.	Nitrification (Pernitric Acid).
	Berthelot	Berl. Berichte, XIV, 1200.	Action upon ether with formation of ethyl peroxide.
	Hartley	Berl. Berichte, XIV, 1390; Chem. News, XLII, 268.	Absorption of the sun's rays by atmospheric Ozone.
	Chappuis	Bull. Soc. Chim. [2], XXXV, 419; Berl. Berichte, XIV, 1394.	Influence upon phosphorescence.
	Papasogli	Gazz. Chim. Ital., XI, 277; Berl. Berichte, XIV, 2303.	Action of CO_2 upon ozonoscopes.
	De Valmagini	Chemikerzeitung, 1880, 242, from Polyt. Notizblatt, XXXV, 91.	Peroxide of manganese as an ozone-carrier.
	Böttger	Chem. Centr., 1880, 351.	Peroxide of manganese as an ozone-carrier.
	"	Chem. Centr., 1880, 719.	Neutral $AuCl_3$ as an ozonoscope.
	Baumann	Zeitsch. physiol. Chem., V, 244; Berl. Berichte, XIV, 2706.	Active oxygen and Ozone.
	Becquerel	Compt. Rend., XCII, 348; J. Chem. Soc., XXXIX, 340.	Specific magnetism of Ozone.
	Schuhmeister	Wien. Akad. Berichte, LXXXIII, 45.	Magnetic constant of Ozone.
	Jeremin	Berl. Berichte, XIV, 1704.	Formation around the arc of electric lamp.
1882	Hautefeuille and Chappuis	Berl. Berichte, XV, 1076.	Reconversion into oxygen during continued electrification.

SECOND INDEX

TO THE

LITERATURE OF PEROXIDE OF HYDROGEN.

Continued from p. 414, *Vol. I Annals.* 1879 *continued.*

1879	Vasey	Chem. News, XL, 47, 91.	Determination of nitrous acid by H_2O_2
1880	Bertrand	Berl. Berichte, XIII, 579.	Titration.
	Schöne	Berl. Berichte, XIII, 1508; Bull. Soc. Chim. [2] XXXIV, 337; Chem. Centr., 1880, 393.	Determinations in atmospheric air with thallium papers.
	"	Berl. Berichte, XIII, 623; Bull. Soc. Chim. [2], XXXIV, 682.	Decomposition in presence of alkalies and alkaline earths.
	"	Ann. de Chem., Vol. 196, 58, 74; J. Am. Chem. Soc., II, 50.	Hydrogen peroxide and the oxides of thallium.
	"	Berl. Berichte, XIII, 627; Bull. Soc. Chim. [2], XXXIV, 683.	Behavior towards KI.
	"	Ann. der Chem., Vol. 197, 137; J. Am. Chem. Soc., II, 181.	Behavior towards the galvanic current.
	Leeds	Berl. Berichte, XIII, 1066, 1132, 1858; J. Am. Chem. Soc., II, 34, 147.	Formation of H_2O_2 and Ozone by action of moist phosphorus upon air.
	Berthelot	Berl. Berichte, XIII, 1132; Compt. Rend., XC, 897; Ann. Chim. Phys. [5], XXI, 160; Bull. Soc. Chim. [2], XXXIV, 78.	Stability of.
	"	Berl. Berichte, XIII, 1018; Compt. Rend., XC, 572; Bull. Soc. Chim. [2], XXXIV, 135; Ann. Chim. Phys. [5], XXI, 164.	Action upon AgO and Ag.

	Berthelot	Berl. Berichte, XIII, 1019; Ann. Chim. Phys. [5], XXI, 176.	Decomposition of $KMnO_4$ by H_2O_2
	"	Compt. Rend., XC, 331; Ann. Chim. Phys. [5], XXI, 194; Bull. Soc. Chim., XXXIII, 246.	Heat of formation.
	"	Compt. Rend., XC, 334; Bull. Soc. Chim, [2], XXXIII, 289; Ann. Chim. Phys. [5], XXI, 153.	Decomposition in presence of alkalies and BaO_2
	"	Ann. Chim. Phys. [5], XXI, 146.	Theory of the catalysis of H_2O_2 by alkalies, BaH_2O_2, AgO, Pt, $KMnO_4$
	"	Compt. Rend., XC, 534; Ann. Chim. Phys. [5], XXI, 153.	Formation and decomposition of the double compounds of BaH_2O_2 and H_2O_2
	"	Compt. Rend., XC, 269; Bull. Soc. Chim. [2], XXIII, 242.	Combination of persulphuric acid with H_2O_2
	Downes and Blunt	Nature, XX,521; Ann. Phys. Beibl., IV, 286.	Decomposition in sunlight.
	Schöne	Ann. der Chem., Vol. 196, 239; J. Am. Chem. Soc., II, 59.	Behavior towards Ozone.
1881	Leeds	Berl. Berichte, XIV, 975.	Action of H_2O_2, Ozone and nascent oxygen upon benzene.
	"	The same, XIV, 1382.	Action upon phenole, napthaline, anthracene, aromatic amines, &c.
	Kingzett	The same, XIV,1220; Chem. News, XLIII, 161.	Quantitative determination.
	Schöne	Berl. Berichte, XIV, 1102; Chem. News, XLIII, 47, 249.	Critique of Kingzett's paper.
	Leeds	Berl. Berichte, XIV, 976; Pharm. J. Trans. [3], XI, 1068.	Production of H_2O_2 by palladium hydrogen in contact with water and air.
	Hamlet	J. Chem. Soc., XXXVIII, 326; Chem. News, XLIII, 175.	Destruction of bacteria by H_2O_2
1882	Traube	Berl. Berichte, XV, 663.	Production in processes of oxidation, structure and re-actions.
	"	The same, XV, 2854; J. Chem. Soc. for 1883, p. 422.	Action of Pb and Pd on CO and H. (CO_2 formed and H_2O_2).
	Radulowitsch	Berl. Berichte, XV, 1461.	Formation during oxidation of terpenes.
	Bert and Reynard	The same, XV, 1585.	Action upon organic substances and upon fermentation.

1882	Béchamp	The same, XV, 1768; Compt. Rend., XCIV, 1601, 1653; J. Chem. Soc. for 1883, 103.	Decomposition by certain organic matters.
	"	Berl. Berichte, XV, 2271; Compt. Rend., XCIV, 1653; J. Chem. Soc. for 1883, p. 103.	Action upon the red coloring matter of the blood and on haematosin.
	"	Berl. Berichte, XV, 3092; Compt. Rend., XCV, 925; J. Chem. Soc. for 1883, p. 227.	Evolution of O from H_2O_2 by fibrine.
	Kingzett	Berl. Berichte, XV, 2750.	Active O and the origin of H_2O_2.
	Schuller	The same, XV, 719.	Formation in combustion.
	Picini	The same, XV, 2221.	Oxidation of titanic acid by H_2O_2.
	Berthelot	The same, XV, 2212.	Electrolysis.
	Kappel	Arch. Pharm. [3], XX, 574; Berl. Berichte, XV, 2359; J. Chem. Soc. for 1883, p. 282.	Formation of Ozone and H_2O_2 by air over Cu and fixed alkalies.
1883	Capranica and Cobosanti	Moleschott, Untersuch., XIII Part 2; Berl. Berichte, XVI, 1104.	
	Classen and Bauer	Berl. Berichte, XVI, 1061; J. Chem. Soc. for 1883, p. 934.	

IV.—*Descriptions of supposed New Species of Birds of the Families Tyrannidæ, Cypselidæ and Columbidæ.*

BY GEORGE N. LAWRENCE.

Read December 1st 1884.

1. Contopus albicollis.

Crown dark hair-brown ; back and upper tail-coverts dark olive-green ; tail feathers dark liver-brown, the outer web of the lateral feather ashy, the inner webs of all are edged with whitish, the ends of the tail-feathers are just edged with dull white ; the quills are blackish-brown, with their inner margins of a very pale ochreous-white, the inner primaries are tipped with whitish. the secondaries narrowly edged and ending with white. and the tertiaries more conspicuously margined with white ; the wing-coverts are dark-brown. largely ending with dull white. forming two bars across the wings ; under wing-coverts dull pale ochreous intermixed with dark ash ; chin and throat white, breast and sides of a rather light cinereous, abdomen and under tail-coverts very pale yellow ; the upper mandible is black, the under is of a light dull yellowish-brown, dusky at the tip ; tarsi and toes black.

Length, 6 inches ; wing, 3.25 ; tail, 2.50 ; bill from front, 0.60 ; tarsus, 0.50.

Habitat, Yucatan. Collected by Geo. F. Gaumer.

Remarks.—This does not require minute comparison with any other species ; the white throat and generally pale colors of the under plumage are distinguishing characters.

2. Chætura Yucatanica.

The upper plumage is deep brownish-black, with the exception of the rump and upper tail-coverts, which are dark ash-color with a wash of fuliginous on the longer tail-coverts ; the tail-feathers are brownish-black, the webs at the end tapering up to the delicate spines, where they are edged with whitish ; wings black, the ends of the inner quills narrowly margined with dull white ; lores black ; the chin, throat and upper part of the breast are light ash, the lower part of the breast and the abdomen are of a dark ash-color, with a smoky tinge on the lower part of the abdomen and on the under tail-coverts ; bill and feet black.

Length to end of spines 4 inches ; wing, 3.90 ; tail to end of spines, 1.65; length of spines, 0.25.

Habitat, Silam, Yucatan. Collected by Geo. F. Gaumer. Type in my collection.

Remarks.—This is a smaller species than my *Chætura Gaumeri* (Annals, Vol. II, p. 245), but resembles it in general coloration, except in having the throat more ashy, and in being darker on the abdomen and on the rump, with the tail blacker, and the webs of the tail-feathers tapering at their ends, these being rounded in *C. Gaumeri.*

In my account of *C. Gaumeri,* I stated that the spines of the tail-feathers were worn off close to the webs, and that this feature was probably caused by the bird's inhabiting rocky cliffs. I have now seen six specimens of this species, all precisely alike in the worn character of the shafts of the tail-feathers. I am of the opinion that the shafts do not extend much beyond the webs. The tail-feathers at the end closely resemble in shape those of *Chætura cinereicauda,* and I judge that the shafts in perfect condition are also similar, i. e., extending only a short distance beyond the webs.

It will be seen by the subjoined communication from Mr. Gaumer, that the two species were obtained at different localities, and at about the same season. He writes : "I would call your attention particularly to the bird numbered 107 (?); this specimen and another which I have, were taken at Silam in June ; the spines are quite long and sharp, while those birds of the interior (*C. Gaumeri*), taken both before and since, have the spines very short and blunt."

3. Engyptila Gaumeri.

Front, as far as the middle of the crown, pure white ; hind part of the crown and the occiput grayish-blue ; hind neck and upper part of back with bright crimson reflections mixed with green on the lower part ; back, wings and upper tail-coverts light brownish-olive; middle tail-feathers olive-brown, the other tail-feathers black, rather narrowly white at their ends ; lesser and middle wing-coverts of a light reddish-brown ; the primaries have their outer webs reddish-brown, of the same color as the wing-coverts, the outer edges whitish towards their ends ; the secondaries have their outer webs of a warmer brown than the primaries. and they are also edged with white as in the primaries ; the inner webs of all the quills are clear cinnamon-red, the primaries at their ends for one and a half inches are dark brown ; the under wing-coverts are deep cinnamon-red ; bill black ; tarsi and toes clear flesh-color—probably crimson in the living bird. *

Length (skin), 10 inches ; wing, 5.75 ; tail, 4.25 ; bill from front, 0.70 ; tarsus, 1.

Habitat, Silam, Yucatan. Type in my collection. Collected by George F. Gaumer, whose name I have conferred upon it. Concerning it Mr. Gaumer writes as follows: "During one week that I was at Silam, I found the doves to be quite rare ; ten were taken, all of which were like the specimen sent you, i. e., with the white front and brilliant reflections on the neck. The specimens from the interior (*E. fulviventris*) are larger and darker. The song of the coast bird is more prolonged and oftener repeated than the other."

Remarks.—This species, in distribution of colors, most resembles *E. Jamaicensis*, but differs from it in being smaller in all its dimensions, except that the bill is perceptibly larger and stronger. The upper plumage is of a much lighter olive, being brownish in *Jamaicencis;* the middle tail-feathers are darker and narrower, with their shafts dark brown, these in the other being of a light reddish-brown ; in the new species the cinnamon-color of the inner webs of the primaries reaches up to the shafts, in *Jamaicensis* it is separated from them by a dusky space. I have before me four specimens of the latter, with which to make comparison.

From *E. albifrons*, it is readily distinguished by its having the front largely pure white, which in *albifrons* is bluish-white and the color more restricted ; also by the more brilliant reflections on the hind neck and by its white throat ; the most marked difference is, that the inner webs of the quills are entirely of a cinnamon-red, whereas in *albifrons* they have only a very pale edging of that color.

Last spring Mr. Gaumer went to Yucatan on his second expedition to that country, to collect specimens in the different branches of natural history. Lately I received from him two small collections of birds, which contained the specimens above described.

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* Chin and throat white; sides of the head, the breast and sides, pale vinaceous; abdomen and under tail coverts white.

V.—*A Catalogue of Chemical Periodicals.*

BY H. CARRINGTON BOLTON.

Read Jan. 5th, 1885.

Introductory.—This Catalogue is intended to contain the titles of the principal chemical periodicals of all countries, from the rise of this literature to the present day. The tendency in serial publications, especially in those of earlier date, to include in a single journal many departments of science, makes it difficult for the bibliographer to draw the line accurately between periodicals devoted to given sciences. Therefore any attempt to classify chemical periodicals is liable on the one hand to too great exclusiveness to satisfy the needs of some, and on the other to too great comprehensiveness and consequent voluminosity.

Chemistry is so commonly treated in periodical literature together with the kindred sciences of physics and of pharmacy, that strictly speaking a full bibliography of chemical periodicals should include all those devoted to the two sciences just named. Moreover there is a large and growing number of technical journals dealing with a special branch of chemical technology, such as brewing, dyeing, gas-making, sugar-refining, etc. ; and these also should be included in any bibliography claiming to be exhaustive. The following catalogue is however confined to the more limited plan, for two reasons;—first, because it is prepared for the convenience of chemists needing a reasonably full list of chemical journals for use in compiling indexes to special topics, in accordance with the scheme of coöperative indexing in charge of a committee of the American Association for the Advancement of Science ; and second, because my "*Catalogue of Sci-*

entific and Technical Periodicals, 1665–1882," published by the Smithsonian Institution, includes works in every department of pure and applied science, and to this comprehensive work we refer librarians and others seeking a wider range. The data in the following pages have been drawn in great measure from the larger catalogue just named ; the works have been brought down to a later date, and society journals have been introduced.

That no bibliography of periodicals which can be classed as chemical, will contain all the literature of chemistry, goes without saying ; chemical papers are unfortunately widely scattered in society publications and in serials devoted to general science ; to include all these is of course out of the question, but a few have been admitted to this list. For a more complete bibliography we refer for society journals to the "Catalogue of Scientific Serials" of Mr. S. H. Scudder (Cambridge, 1879, 8vo), and for journals of general science to our own "Catalogue" already mentioned.

Plan of Catalogue.—The arrangement of titles is strictly alphabetical, the articles and the adjective *New* alone excepted. The different titles borne by a periodical at different periods, are arranged in chronological order under the first or earliest title.

Cross-references have been freely introduced, and are of three kinds : 1st, from the later to the first title of a periodical which has undergone changes in title ; 2d, from short titles in common use to the accurate bibliographical designations ; 3d, from the names of editors to the periodicals conducted by them. Besides these, in the case of societies, references are made from the cities in which the societies are located, and from the proper designation of the societies to the titles of the journals published by them. A geographical index, arranged by counties and cities, will be found at the close.

CATALOGUE

OF

CHEMICAL PERIODICALS.

EXPLANATION OF SIGNS.

\+ Following a date signifies current at the date in question.
‖ Following a date signifies publication discontinued.

ACADÉMIE DES SCIENCES, Paris.
See Comptes-rendus hebdomadaires des séances [etc.].

ACADÉMIE IMPÉRIALE DES SCIENCES DE ST. PÉTERSBOURG.
See Mélanges physiques et chimiques [etc.].

1. AFHANDLINGAR I FYSIK, KEMI OCH MINERALOGI. Utgifne af W. Hisinger och J. Berzelius. 6 vols., 8vo. Stockholm, 1806–'18. Vol. I, 1806; II, 1807; III, 1810; IV, 1815; V, VI, 1818.

2. AGENDA DU CHIMISTE. 16mo. Paris, 18**–'82+

AKADEMIE DER WISSENSCHAFTEN ---- WIEN.
See Monatshefte für Chemie.

ALBERTONI, P.
See Revista di chimica e farmaceutica.

3. ALLGEMEINE CHEMIKER ZEITUNG. Central-Organ für Chemiker, Techniker, Ingenieure, Maschinenbauer, Fabrikanten chemisch-technischer Apparate. Correspondenzblatt chemisch-technischer und Gewerbe-Vereine.

Chemisches Central-Annoncenblatt. Herausgegeben von G. Krause. 8 vols., 4to. Cöthen, 1877–'84+
In 1879 *the prefix* ALLGEMEINE *was dropped.*

4. ALLGEMEINE CHEMISCHE BIBLIOTHEK DES NEUNZEHNTEN JAHRHUNDERTS. Herausgegeben von J. B. Trommsdorff. 5 vols., 8vo. Erfurt, 1801–'05.

ALLGEMEINE NORDISCHE ANNALEN DER CHEMIE.
See Nordische Blätter für Chemie.

5. ALLGEMEINES JOURNAL DER CHEMIE. Herausgegeben von Alex. Nic. Scherer. 10 vols., 8vo. Leipzig, 1798–1803.

Continued under the title:

[a.] Neues allgemeines Journal der Chemie, von Klaproth, Hermbstädt, Scherer, J. B. Richter, J. B. Trommsdorff, herausgegeben von Ad. Ferd. Gehlen. 8 vols., 8vo. Leipzig, 1803–'06.

Continued under the title:

[b.] Journal für die Chemie, Physik [*from* vol. IV] und Mineralogie, von Bucholz, Crell, Hermbstädt, Klaproth, Richter, Ritter, Trommsdorff, herausgegeben von A. F. Gehlen. 9 vols., 8vo. Berlin, 1806–'10.

Continued under the title:

[c.] Journal für Chemie und Physik, in Verbindung mit J. J. Bernhardi, J. Berzelius, C. F. Bucholz, L. von Crell, A. F. Gehlen [*and others*], herausgegeben von J. S. C. Schweigger. 69 vols., 8vo. Nürnberg, 1811–'33.

Changes in the title as follows:

1st Series, vols. I–XXX, 1811–'20, *also under the title,* Beiträge zur Chemie und Physik.

2d Series, vols. XXXI–LX, 1821–'30, *also under the title,* Jahrbuch der Chemie und Physik herausgegeben von Schweigger und Meinecke.

3d Series, vols. LXI–LXIX, 1831–'33, *also under the title,* Neues Jahrbuch der Chemie und Physik. *From* 1829, *edited by* Fr. W. Schweigger-Seidel.

United in 1834 *with the* Journal für technische und oekonomische Chemie *and continued under the title:*

[d.] Journal für praktische Chemie, herausgegeben von Otto Linné Erdmann, F. W. Schweigger-Seidel (und R. F. Marchand). [*From* 1853, *edited by* O. L. Erdmann *and* Gustav Werther.] 108 vols., 8vo. Leipzig, 1834–'69.

[e.] Neue Folge. Herausgegeben von Hermann Kolbe. [*From* 1879 *by* H. Kolbe *and* Ernst von Meyer.] 30 vols., 8vo. Leipzig, 1870–'84+

Sach- und Namen-Register zu Band I–XXX. Leipzig, 1844.

Ditto, ditto, Band XXXI–LX. Leipzig, 1854.

Ditto, ditto, bearbeitet von Friedrich Gottschalk, Band LXI–XC. Leipzig, 1865.

Ditto, ditto, Band XCI–CVIII. Leipzig, 1871.

6. ALMANACCO DI CHIMICA AGRICOLA. Dal A. Selmi. 6 vols., 16mo. Milano, 1873–'78 [+ ?]

7. ALMANACH DE LA CHIMIE, par H. du M. 8 vols., 18mo. Rouen et Paris, 1854–'61.

8. ALMANACH FÜR SCHEIDEKÜNSTLER UND APOTHEKER. Herausgegeben von J. F. A. Göttling. 23 vols., 8vo. Weimar, 1780–1802.

Continued under the title:

[a.] Taschenbuch für Scheidekünstler und Apotheker, herausgegeben von Ch. Fr. Bucholz. 17 vols. (XXIV–XL), 8vo. Weimar, 1803–'19.

Continued under the title:

[b.] Trommsdorff's Taschenbuch für Chemiker und Pharmaceuten. 10 vols. (XLI–L), 8vo. Jena, 1820–'29.||

Register, 1780–1803. 1 vol., 8vo.

Edited from 1780–1802, *by* J. F. A. Göttling; 1803–'15, C. F. Bucholz; 1806–'17, C. F. Bucholz *with* Wilh. Meissner; 1818, C. F. Bucholz *with* Rud. Brandes; 1819, Rud. Brandes; 1820–'29, J. B. Trommsdorff.

ALMSTRÖM, P. O.
See Tekno kemisk Journal.

AMERICAN CHEMICAL REVIEW.
See Chemical Review and Journal [*a*].

AMERICAN CHEMICAL SOCIETY.
See Journal of the.

9. AMERICAN CHEMICAL JOURNAL. Edited, with the aid of chemists at home and abroad, by Ira Remsen. 6 vols., 8vo. Baltimore, Md., 1879–'84+

10. AMERICAN (THE) CHEMIST. A monthly journal of theoretical, analytical, and technical chemistry. Edited by Chas. F. Chandler and W. H. Chandler. 6 vols. and 6 nos., 4to. New York, 1870–'77.‖

11. AMERICAN (THE) LABORATORY. A bi-monthly journal of the progress of chemistry, pharmacy, medicine, recreative science, and the useful arts. 4to. Boston, 1875.

12. ANALYST (THE), including the proceedings of the "Society of Public Analysts." A monthly journal of analytical chemistry. Edited [in 1882] by G. W. Wigner and J. Muter. 9 vols., 8vo. London, 1876–'84.

ANNALEN DER CHEMIE UND PHARMACIE
See Annalen der Pharmacie.

ANNALEN DER CHEMISCHEN LITERATUR.
See Bibliothek der neuesten physisch-chemischen – – – Literatur.

13. ANNALEN DER PHARMACIE. Eine Vereinigung des Archives des Apotheker-Vereins im nördlichen Teutschland, B. XL; und des Magazins für Pharmacie und Experimentalkritik, B. XXXVII. Herausgegeben von Rudolph Brandes, Ph. Lorenz Geiger, und Justus Liebig. 10 vols., 8vo. Lemgo und Heidelberg, 1832–'34.

Continued (*from vol.* XI, 1834) *under the title:*

[a.] Annalen der Pharmacie. Vereinigte Zeitschrift des Neuen Journals der Pharmacie für Aerzte, Apotheker und Chemiker, Band, XXVIII; des Archivs des Apothekervereins im nördlichen Deutschland, Band, XLIX; und des Magazins für Pharmacie und Experimental-Kritik, Band XLVI. Von Johann Bartholomä Trommsdorff, Rudolph Brandes, Philipp Lorenz Geiger, und Justus Liebig. 22 vols. (XI–XXXII), 8vo. Heidelberg, 1834–'39.

Vols. XVII–XXII, *edited by* J. B. Trommsdorff, Justus Liebig, *and* Emanuel Merck. Vols. XXIII–XXVI, *edited by* Justus Liebig, Emanuel Merck, *and* Friedrich Mohr. Vols. XXVII–XXXII, herausgegeben unter Mitwirkung der HH. Dumas in Paris und Graham in London, von Friedrich Wöhler und Justus Liebig.

Continued under the title:

[**b.**] Annalen der Chemie und Pharmacie. Unter Mitwirkung der HH. Dumas in Paris und Graham in London, herausgegeben von Friedrich Wöhler und Justus Liebig. 136 vols. (XXXIII–CLXVIII), 8vo. Heidelberg, 1840–1873.

From vol. XLI *the names* Dumas and Graham *are dropped. From* vol. LXXVII (1851), *edited by* Friedrich Wöhler, Justus Liebig, *and* Hermann Kopp; neue Reihe Band I. *From* vol. CLIX (1871), *edited by the same, together with* E. Erlenmeyer *and* J. Volhard.

Continued under the title:

[**c.**] Justus Liebig's Annalen der Chemie und Pharmacie. Herausgegeben von Friedrich Wöhler, Hermann Kopp, Emil Erlenmeyer, Jacob Volhard [*later, by the same, with* A. W. Hofmann, Aug. Kekulé]. 58 vols. (CLXIX–CCXXVI), 8vo. Leipzig und Heidelberg, 1873–'84+

[**d.**] Supplement-Band I, 1861; II, 1862–'63; III, 1864–'65; IV, 1865–'66; V, 1867; VI, 1868; VII, 1870; VIII, 1872.

Autoren- und Sach-Register zu den Bänden I–C (Jahrgang, 1832–1856) der Annalen der Chemie und Pharmacie. Bearbeitet von G. C. Wittstein. 8vo. Leipzig und Heidelberg, 1861.

Autoren- und Sach-Register zu den Bänden CI–CXVI (Jahrgang, 1857–1860) der Annalen der Chemie und Pharmacie. Bearbeitet von G. C. Wittstein. 1 vol., 8vo. Leipzig und Heidelberg, 1861.

Autoren- und Sach-Register zu den Bänden CXVII–CLXIV und den Supplementbänden I–VIII, (1861–1872) der Annalen der Chemie und Pharmacie. Bearbeitet von Friedrich Carl. 1 vol., 8vo. Leipzig und Heidelberg, 1874.

General-Register zu den Bänden CLXV–CCXX (1873–1883), von Liebig's Annalen der Chemie (früher Annalen der Chemie und Pharmacie), bearbeitet von Friedrich Carl. 1 vol., 8vo. Leipzig, 1885.

Cf. Magazin für Pharmacie.

ANNALEN DER PHYSIK UND CHEMIE. Poggendorff. *See* Journal der Physik. Gren.

14. ANNALES DE CHIMIE, ou Recueil de mémoires concernant la chimie et les arts qui en dépendent, [*from* vol. XXXIII] et spécialement la pharmacie. Par de Morveau, Lavoisier, Monge, Berthollet, de Fourcroy, de Dieterich, Hassenfratz, et Adet. 96 vols., 8vo. Paris, 1789–1816.

Vols. I, II, *and* III *were reprinted at Paris in* 1830.

Tables des matières. 3 vols. Paris, 1801, 1807, 1821.

Continued under the title:

[**a.**] Annales de chimie et de physique, par Gay-Lussac et Arago. Deuxième série.. 78 vols., 8vo. Paris, 1817–'40.

Tables des matières. 3 vols., 8vo. Paris, 1831–'41.

Continued under the title:

[**b.**] Annales de chimie et de physique, par Arago, Chevreul, Dumas, Pélouze, Boussingault, Regnault. Avec une revue des travaux de chimie et de physique publiées à l'étranger, par Wurtz et Verdet. Troisième série. 69 vols., 8vo. Paris, 1841–'63.

Tables des matières. 2 vols., 8vo. Paris, vols. I–XXX, 1851 ; vol. XXXI–LXIX, 1866.

Continued under the title:

[**c.**] Annales de chimie et de physique, par Chevreul, Dumas, Pélouze, Boussingault, Regnault, avec la collaboration de Wurtz. Quatrième série. 30 vols., 8vo. Paris, 1864–'73.

Table des matières. Vols. I–XXX. Paris, 1874.

[**d.**] Cinquième série. Par Chevreul, Dumas, Boussingault, Wurtz, Berthelot, Pasteur, avec la collaboration de de Bertin. 30 vols., 8vo. Paris, 1874–'84+

15. ANNALI DI CHIMICA [*from* vol. IV] e storia naturale, ovvero raccolta di memorie sulle scienza, arti e manufatture ad esse relative, di L. Brugnatelli. 21 vols., 8vo. Pavia, 1790–1802.‖

Vol. XXI contains index.

ANNALI DI CHIMICA APPLICATA ALLA MEDECINA. Polli. *See* Giornale di farmacia, chimica e scienza accessorie.

16. ANNALI DI FISICA, CHIMICA E MATEMATICHE, col bullettino dell' industria, meccanica e chimica, diretti dall' ingegnere G. A. Majocchi. 28 vols., 8vo. Milano, 1841–'47.

Continued under the title:

[**a.**] Annali di fisica, chimica e scienze affini, col bollettini di farmacia e di technologia, redatti da G. A. Majocchi e F. Selmi, [*from* vol. III] e P. A. Boscarelli. Seconda serie. 4 vols., 8vo. Torino, 1850.‖

ANNALI DI FISICA, dell' Abbate F. C. Zantedeschi. *See* Raccolta fisico-chemico-italiano.

17. ANNALS OF CHEMICAL MEDICINE, including the application of chemistry to physiology, pathology, therapeutics, pharmacy, toxicology, and hygiene. Edited by J. L. W. Thudicum. 2 vols., 8vo. London, 1880 '81+

18. ANNALS (THE) OF CHEMICAL PHILOSOPHY, [etc.] By W. Maugham. 2 vols., 8vo. London, 1828 '29.

19. ANNALS OF CHEMISTRY, [etc.], by de Morveau, Lavoisier, [*and others.*] Translated from the French. 1 vol., 8vo. London, 1791.

This is a translation of the fifth volume of the Annales de chimie.

20. ANNALS (THE) OF CHYMISTRY AND PRACTICAL PHARMACY. Being a weekly summary of the discoveries of philosophers, chiefly continental and transatlantic, in their applications to the chemistry of medicine, agriculture, manufactures, and to the several branches of physics, electricity, galvanism, photography, etc. 1 vol., 8vo. London, 1843.

21. Annals of Pharmacy and Practical Chemistry. Edited by W. Bastick and W. Dickenson. 3 vols., 8vo. London, 1852–'54.‖

22. Annals of Philosophy; or Magazine of Chemistry, Mineralogy, Mechanics, Natural History, Agriculture, and the Arts. By Thomas Thomson. 16 vols., 8vo. London, 1813–'20.

New series. [Edited by Richard Phillips.] 12 vols., 8vo. London, 1821–'26.

United in 1827 *with the* Philosophical Magazine and Journal. *See* Philosophical Magazine.

23. Annuaire des produits chimiques, de la droguerie et de l'épicerie en gros, contenant la liste complète des fabricants, etc., de France, de l'Italie, de Belgique, et de la Suisse. 4 vols., 8vo. Paris, 1874–'78.

24. Annuaire de chimie, comprenant les applications de cette science à la médecine et à la pharmacie, ou répertoire des découvertes et des nouveaux travaux en chimie faits dans les diverses parties de l'Europe, par E. Millon et J. Reiset, avec la collaboration de F. Hoefer et de Nicklès. 7 vols., 8vo.. Paris, 1845–'51.‖

Annuaire de Chimie - - - par Laurent et Gerhardt. *See* Comptes-rendus mensuels des travaux chimiques, etc.

25. Annuaire des sciences chimiques, ou Rapport sur les progrès des sciences naturelles présenté à l'académie de Stokolm [*sic*]. Par Berzelius. Supplément à son Traité de chimie. Traduit en Français par H. D. 8vo. Paris, 1837.

See Rapport annuel sur les progrès des sciences; *also* Årsberättelse om Framstegen i Fysik och Kemi.

26. Annual Report of the Progress of Chemistry and the allied sciences, physics, mineralogy, and geology; including the application of chemistry to pharmacy, the arts and manufactures. By Justus Liebig and H. Kopp with the coöperation of H. Buff, Frederick Knapp, Ernest Dieffenbach, Charles Ettling, Henry Will, Frederick Zamminer. Edited by A. W. Hofmann and Warren de la Rue. 1847–'53. 7 vols., 8vo. London, 1849–'55.

See Jahresbericht über die Fortschritte der reinen - - - Chemie. Giessen.

27. Annuario almanacco pei chimici, farmacisti e medici italiani, redatto per cura del farmacista Ign. Cugusi-Persi da Cagliari. 5 vols., 16mo. Milano, 1874–'79.

28. Annuario chimico italiano dell' anno 1845, diretto da Francesco Selmi e compilato dal medesimo in compagnia dei Signori Giuseppi Parmeggiani e Giovanni Giorgini. 1 vol., 8vo. Modena, 1846.

29. Annuario delle scienze chimiche e naturali. 1 vol., 8vo. Verona, 1840.

30. Annuario delle scienzi chimiche, farmaceutiche, e medico-legali ad uso dei farmacisti e medici, in continuazione del Supplimento al trattato di farmacia, del Sign. Virey ; della Gazzetta eclettica di farmacia e chimica. 1 vol., 8vo. Mantova, 1840.

Continued under the title :

[**a.**] Annuario delle scienze chimiche, farmaceutiche e medico-legali, contenente tutte le scoperte relative a queste scienze, la relazione di lavori chimici e naturali, delle riunioni degli scienziati italiani e stranieri. di quelli particolari di J. J. Berzelius, e la traduzione della chimica organica di J. Liebig. Redattore G. B. Sembenini. 9 vols., 8vo. Mantova, 1841–'49.

Cf. Gazzetta eclettica di farmacia e chimica.

31. Anti-Adulteration Review. — vols. London, 1871–'80+

32. Archiv der Agriculturchemie für denkende Landwirthe. Herausgegeben von Sig. F. Hermbstädt. 7 vols., 8vo. Berlin, 1803–'18. ‖

33. Archiv for Pharmaci, redigeret af S. M. Trier. 3 vols., 8vo. Kjøbenhavn, 1844–'46.

Continued under the title:

[a.] Archiv for Pharmaci og technisk Chemi med deres Grundvidenskaber. Redigeret af S. M. Trier. Det technisk-chemiske Afsnit redigeret af P. Faber. 34 vols. (IV–XXXVII), 8vo. Kjøbenhavn, 1847–'80+
Index. Vols. I–XV. 1844–'58. Kjøbenhavn, 1859.

34. Archiv für die gesammte Naturlehre. In Verbindung mit Bischoff, Förstmann, C. G. Gmelin, Grischow, F. W. von Paula Gruithuisen, Hallaschka, Pl. Heinrich, A. von Humboldt, John, Kleefeldt, Lichtenberg, Marx, Olbers, Pleischl, Prechtl, Schmidt, Schön, Späth, Wollner, und Zimmerman, herausgegeben von C. W. G. Kastner. 27 vols., 8vo. Nürnberg, 1824–'35.

Vols. XIX–XXVII *also under the title:*

Archiv für Chemie und Meteorologie, in Verbindung mit mehreren Gelehrten, herausgegeben von C. W. G. Kastner. 9 vols. (I–IX), 8vo. Nürnberg, 1830–'35.

Archiv für Chemie und Meteorologie.
See Archiv für die gesammte Naturlehre.

Archiv für physiologische und pathologische Chemie.
See Beiträge zur physiologischen und pathologischen Chemie.

35. Archiv für die theoretische Chemie. Herausgegeben von Alex. Nic. Scherer. 1 vol., 8vo. Jena und Berlin, 1800–'02.

36. Archiv für die thierische Chemie. Herausgegeben von Johann Horkel. 1 vol., 8vo. Halle, 1800, '01.

37. Årsberättelse om Framstegen i Physik och Chemi till Kongl. Vetenskaps-Akademien afgiven af Jac. Berzelius. 1821–'40. 20 vols., 8vo. Stockholm, 1822–'41.

Continued under the title:

[a.] Årsberättelse om Framstegen i Kemi och Mineralogi afgiven af Jac. Berzelius. 1841–'47. 7 vols., 8vo. Stockholm, 1841–'48.

Followed by:

[b.] Årsberättelse om Framstegen i Kemi till Kongl. Vetenskaps-Akademien afgiven af L. F. Svanberg. 1847–'49. 3 vols., 8vo. Stockholm, 1849–'51.

Sak- och Namn-Register öfver alla af Berzelius - - - afgifna Årsberättelser (1821–'47). På Kongl. Vetenskaps-Akademiens föranstaltande utgifvet af A. Wiemer. 1 vol., 8vo. Stockholm, 1850.

Cf. Rapport annuel sur les progrès des sciences physiques et chimiques.

Artus, W.

See Jahrbuch für ökonomische Chemie ; *also* Vierteljahresschrift für technische Chemie.

38. Auswahl aller eigenthümlichen Abhandlungen und Beobachtungen in der Chemie, mit einigen Verbesserungen und Zusätzen. Herausgegeben von Lorenz Crell. 5 vols., 8vo. Leipzig, 1786, '87.

Cf. Crell, Lorenz.

39. Auswahl vorzüglicher Abhandlungen aus den sämmtlichen Bänden der französischen Annalen der Chemie zur vollständigen Benutzung derselben durch Ergänzung der von ihrem Anfange an den chemischen Annalen einverleibten Aufsätzen für deutsche Scheidekünstler von Lorenz von Crell. 1 vol., 8vo. Helmstadt, 1801.

Cf. Crell, Lorenz.

Bastick (W.) and Dickenson (W).
See Annals of Pharmacy and Practical Chemistry.

Beiblätter zu den Annalen der Physik und Chemie.
See Journal der Physik.

Beilstein's Zeitschrift für Chemie.
See Kritische Zeitschrift für Chemie.

40. Beiträge zur Chemie in Uebersetzung oder vollständigen Auszügen neuer chemischer Abhandlungen, sammt einigen neuen Aufsätzen. Herausgegeben von F. A. X. von Wasserberg. 1 vol., 8vo. Wien, 1791.

Beiträge zur Chemie und Physik, von J. S. C. Schweigger. *See* Allgemeines Journal der Chemie.

41. Beiträge zur chemischen Kenntniss der Mineralkörper. Herausgegeben von M. H. Klaproth. 6 vols., 8vo. Berlin und Stettin, 1795–1815.

42. Beiträge zur Erweiterung und Berichtigung der Chemie. Herausgegeben durch C. F. Bucholz. 3 vols., 8vo. Erfurt, 1799–1802.

43. Beiträge zur physiologischen und pathologischen Chemie und Mikroscopie in ihrer Anwendung auf die praktische Medicin, unter Mitwirkung der Mitglieder des Vereins für physiologische und pathologische Chemie und anderer Gelehrten, herausgegeben von Franz Simon. 1 vol., 8vo. Berlin, 1843.

Continued under the title:

[**a.**] Archiv für physiologische und pathologische Chemie und Mikroscopie in ihrer Anwendung auf die praktische Medicin. Organ für die Fortschritte der gesammten medicinischen Chemie im In- und Auslande. Unter Mitwirkung mehrerer Gelehrten des In- und Auslandes als Fortsetzung der von Franz Simon in Berlin gegründeten Zeitschrift "Beiträge, etc.," herausgegeben und redigirt von J. F. Heller. 4 vols. (I–IV), 8vo. Wien und Berlin, 1844–'47.

Continued under the title:

[**b.**] Archiv für physiologische und pathologische Chemie und Mikroscopie mit besonderer Rücksicht auf die medicinische Diagnostik und Therapie. Herausgegeben von Joh. Florian Heller. Neue Folge. 2 vols. (V, VI), 8vo. Wien, 1852–'54.‖

Bennewitz, Paul.

See Deutscher Chemiker-Kalender; *also,* Technisch-chemischer Kalender.

Bergé, Henri.

See Chimiste (Le).

44. Berichte der deutschen chemischen Gesellschaft. 17 vols. [*from* 1874 *each volume in two parts*], 8vo. Berlin, 1868–'84+

Generalregister über die ersten zehn Jahrgänge (1868–1877) der Berichte der deutschen chemischen Gesellschaft zu Berlin. Bearbeitet von C. Bischoff. 1 vol., 8vo. Berlin, 1880.

BERLIN, DEUTSCHE CHEMISCHE GESELLSCHAFT.
See Berichte der deutschen ——.

45. BERLINISCHES JAHRBUCH DER PHARMACIE. 1 vol., 12mo. Berlin, 1795.

Continued under the title:

[**a.**] Berlinisches Jahrbuch für die Pharmacie und für die damit verbundenen Wissenschaften. 42 vols. (II–XLIII). 12mo. Berlin, 1796–1840.||

From 1803–'10 *published with the additional title:* Neues Berlinisches Jahrbuch für die Pharmacie, [*edited by* F. A. Gehlen *and* Val. Rose]. *From* 1811–'14, *with the additional title:* Neues Jahrbuch der Pharmacie, herausgegeben von W. Döbereiner. *From* 1815–'29, *with the additional title:* Deutsches Jahrbuch für die Pharmacie. *Edited from* 1818–'20 *by* C. W. G. Kastner; 1821–'25, G. H. Stoltze; 1826–'29, Wilhelm Meissner; 1830, '31, A. Lucas; 1833–'40, Lindes.

BERZELIUS, J.
See Afhandlingar i Fysik, Kemi [etc.]; *also*, Årsberättelse om Framstegen i Physik och Chemi; *also*, Rapport annuel sur les progrès des sciences physiques et chimiques.

BERZELIUS' JAHRESBERICHT.
See Jahresbericht über die Fortschritte der physischen Wissenschaften.

BIBLIOTECA DI FARMACIA.
See Giornale di farmacia - - - Cattaneo.

46. BIBLIOTHEK DER NEUESTEN PHYSISCH-CHEMISCHEN, METALLURGISCHEN, technologischen und pharmaceutischen Literatur. Herausgegeben von S. F. Hermbstädt. 4 vols., 8vo. Berlin, 1788–'95.

Continued under the title:

[**a.**] Annalen der chemischen Literatur. Herausgegeben von Wolf. 1 vol., 8vo. Berlin, 1802.

BIEDERMANN, R.
See Centralblatt für Agriculturchemie; *also,* Chemiker-Kalender; *also,* Technisch-chemisches Jahrbuch.

47. BOSTON JOURNAL OF CHEMISTRY. Devoted to chemistry, as applied to medicine, agriculture, and the arts. [*From* vol. v, devoted to the science of home life, the arts, agriculture, and medicine.] Edited by Jos. R. Nichols. 14 vols., 4to. Boston, (July) 1866–'80.

Continued under the title:

[a.] Boston Journal of Chemistry and Popular Science Review. Devoted to chemistry, pharmacy, geology, agriculture, astronomy, hygiene, medicine, practical arts, home science, [etc.]. 2 vols. (XV, XVI), 4to. Boston, 1881, '82.

Continued under the title:

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71. Chemist (The) and Meteorological Journal. July 8th to Dec. 9th, 1826. John R. Cotting, Editor. Amherst, Mass. 8vo. *n. d.*

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85. GAZZETTA ECLETTICA DI CHIMICA TECNOLOGICA. Red.: Sembenini. — vols., 8vo. Verona, 1833, '34.

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[a.] Observations et mémoires sur la physique, sur l'histoire naturelle et sur les arts et métiers. Par l'abbé Rozier. 1 vol., 4to. Paris, 1773.

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99. Jahresbericht über die Fortschritte auf dem Gebiete der reinen Chemie. Bearbeitet im Verein mit mehreren Fachgenossen und herausgegeben von Wilhelm Staedel. 1873–'82. 10 vols., roy. 8vo. Tübingen, 1874–'84+

100. Jahresbericht über die Fortschritte der Agriculturchemie, mit besonderer Berücksichtigung der Pflanzenchemie und Pflanzenphysiologie. Herausgegeben von Robert Hoffmann. 1858–'64. 6 vols., 8vo, Berlin, 1860–'65.

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[**a.**] Jahresbericht über die Fortschritte auf dem Gesammtgebiete der Agriculturchemie. Fortgesetzt von Edward Peters. [*From* 186*, *edited by* Th. Dietrich, H. Hellriegel, J. Flittbogen, H. Ulbricht.] 14 vols. (vii–xx), 8vo. Berlin, 1864–'77.

Neue Folge. von A. Hilger. 5 vols. (xxi–xxv). Berlin. 1878–'83+

From 1874, *annual volumes are divided into portions having independent pagination and bearing the following titles:*

Jahresbericht über die Fortschritte der Chemie des Bodens, der Luft und des Düngers. Herausgegeben von Th. Dietrich.

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Jahresbericht über die Fortschritte der Chemie der Thiernährung und der chemischen Technologie der landwirthschaftlichen Nebengewerbe. Herausgegeben von J. König und A. Hilger.

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161. JAHRESBERICHT ÜBER DIE FORTSCHRITTE DER CHEMISCHEN TECHNOLOGIE für Fabrikanten, Hütten- und Forstleute, Cameralisten. Chemiker und Pharmaceuten. Herausgegeben von Joh. Rud. Wagner. 6 vols., 8vo. Leipzig, 1855–'60.

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[a.] Jahresbericht über die Fortschritte und Leistungen der chemischen Technologie und technischen Chemie. Herausgegeben von J. R. Wagner. 9 vols. (VII–XV), 8vo. Leipzig, 1861–'69.

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[b.] Jahresbericht über die Fortschritte und Leistungen der chemischen Technologie und technischen Chemie, (*from* vol. XVIII,) mit besonderer Berücksichtigung der Gewerbsstatistik. Herausgegeben von J. R. Wagner. Neue Folge. 11 vols. (XVI–XXVI), 8vo. Leipzig, 1870–'80.

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[c.] Wagner's (R. von) Jahresbericht über die Leistungen der chemischen Technologie, mit besonderer Berücksichtigung der Gewerbestatistik für das Jahr 1880–'83. Herausgegeben von F. Fischer. 3 vols., 8vo. Leipzig. 1881–'84+

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162. JAHRESBERICHT ÜBER DIE FORTSCHRITTE DER PHYSISCHEN WISSENSCHAFTEN. Von Jacob Berzelius. Aus dem schwedischen übersetzt von C. G. Gmelin [*later*,] und F. Wöhler. 20 vols., 8vo. Tübingen, 1822–'41.

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[a.] Jahresbericht über die Fortschritte der Chemie und Mineralogie. Eingereicht an die schwedische Akademie der Wissenschaften. Von Jacob Berzelius. [*From* 1849–'51, *edited by* L. F. Svanberg.] Aus dem schwedischen übersetzt von F. Wöhler. 10 vols. (XXI–XXX), 8vo. Tübingen, 1842–'51.||

Register. Vols. I–XVII, 1839; I–XXV, 1847.

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[a.] Jahresbericht über die Fortschritte der Chemie und verwandter Theile anderer Wissenschaften. Von Hermann Kopp und Heinrich Will. [*In* 1861, unter Mitwirkung von Th. Engelbach, W. Hallwachs, A. Knop, herausgegeben von Hermann Kopp und Heinrich Will. *In* 1864, unter Mitwirkung von C. Bohn und Th. Engelbach, herausgegeben von Heinrich Will. *In* 1868, unter Mitwirkung von Th. Engelbach, Al. Naumann, W. Städel, herausgegeben von Adolph Strecker. *In* 1870, unter Mitwirkung von K. Birnbaum, W. Dittmar, F. Hoppe-Seyler, A. Laubenheimer, A. Michaelis, F. Nies, Th. Zincke, K. Zöppritz, herausgegeben von Alexander Naumann. *In* 1875, unter Mitwirkung von K. Birnbaum, C. Boettinger, C. Hell, H. Klinger, A. Laubenheimer, E. Ludwig, A. Michaelis, A. Naumann, F. Nies, H. Salkowski, Zd. H. Skraup, K. Zöppritz, herausgegeben von F. Fittica. *In* 1882, unter Mitwirkung von A. Bornträger, A. Elsas, E. Erdmann, C. Hell, H. Klinger, E. Ludwig, A. Naumann, F. Nies, H. Salskowski, G. Schultz, herausgegeben von F. Fittica.] 1857–'82. 26 vols. (x–xxxv), 8vo. Giessen, 1858–'84+

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104. Jahresbericht über die Fortschritte der Thierchemie. Herausgegeben von Richard Maly. 1871–'83. 13 vols., 8vo. Wien, 1872–'84+

105. Journal de chimie et de physique, ou Recueil périodique des découvertes dans les sciences chimiques et physiques, tant en France que chez l'étranger. Par J. B. van Mons. 6 vols., 12mo. Bruxelles, An x [1801]–xii [1804].

Cf. Journal de chimie pour servir [etc.].

106. JOURNAL DE CHIMIE MÉDICALE, DE PHARMACIE ET DE TOXICOLOGIE. Rédigé par Chevallier, Fée, Guibourt, Julia-Fontenelle, Laugier, Orfila, Payen, Gabrielle Pelletan, Lassaigne, Achard Richard, Robinet, Segalas d'Etchepare. 10 vols., 8vo. Paris, 1825–'34.

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[**a.**] Journal de chimie médicale, de pharmacie et de toxicologie. Revue des nouvelles scientifiques nationales et étrangères. Par les membres de la Société de chimie médicale. Deuxième serie. 10 vols. (I–X), 8vo. Paris, 1835–'44.

Table générale des matières et des auteurs de la deuxième série du Journal de chimie médicale, de pharmacie et de toxicologie; de 1835–'44. 1 vol., 8vo. Paris, 1845.

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[**b.**] Journal de chimie médicale, de pharmacie, de toxicologie et revue des nouvelles scientifiques nationales et étrangères. Par les membres de la Société de chimie médicale, Béral, Chevallier, Dumas, Fée, Guibourt, Lassaigne, Orfila, Payen, E. Péligot, G. Pelletan, Pelouze, A. Richard, S. Robinet. Troisième série. 10 vols. (I–X), 8vo. Paris, 1845–'54.

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[**c.**] Journal de chimie médicale, de pharmacie, de toxicologie et revue des nouvelles scientifiques nationales et étrangères. Publié sous la direction de A. Chevallier. Quatrième série. 10 vols. (I–X), 8vo. Paris, 1855–'64.

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[**d.**] Journal de chimie médicale, de pharmacie, de toxicologie et revue des nouvelles scientifiques nationales et étrangères. Revue industrielle. Publié sous la direction de A. Chevallier. Cinquième série. 12 vols. (I–XII), 8vo. Paris, 1865–'76.

United in March, 1876, *with the* Répertoire de pharmacie *and continued under the title;* Répertoire de pharmacie et journal de chimie médicale réunis, *q. v.*

107. JOURNAL DE CHIMIE pour servir de complément aux Annales de chimie et d'autres ouvrages périodiques français de cette science. Rédigé par J. B. van Mons. 6 vols., 8vo. Bruxelles, 1792–1804.

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See Zhurnal russkova khimicheskova (etc.).

JOURNAL DE PHARMACIE.
See Bulletin de pharmacie.

JOURNAL DE PHYSIQUE, DE CHIMIE - - - - Laméthérie.
See Introduction aux observations sur la physique [c.].

JOURNAL DER CHEMIE.
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[a.] Neues Journal der Pharmacie für Aerzte, Apotheker und Chemiker. Herausgegeben von Joh. B. Trommsdorff. 27 vols., 8vo. Leipzig, 1817–'34.

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109. JOURNAL DER PHYSIK. Herausgegeben von Fr. Albrecht Carl Gren. 8 vols., 8vo. Halle und Leipzig, 1790–'94.

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[a.] Neues Journal der Physik. Herausgegeben von Fr. Albrecht Carl Gren. 4 vols. (I–IV), 8vo. Halle und Leipzig, 1794–'98.

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[b.] Annalen der Physik. Angefangen von Fr. Albr. Carl Gren, fortgesetzt von Ludwig Wilhelm Gilbert. [*From* vol. IV, Herausgegeben von Ludwig Wilhelm

Gilbert.] 30 vols. (I–XXX), 8vo. Halle, 1799–1808.

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Supplement zu Band XII. 1803.

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[c.] Annalen der Physik und der physikalischen Chemie. Herausgegeben von Ludwig Wilhelm Gilbert. Dritte Reihe. 16 vols. (I–XVI *and* LXI–LXXVI), 8vo. Halle, 1819–'24.

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[d.] Annalen der Physik und Chemie. Herausgegeben von Julius C. Poggendorff. 30 vols. (I–XXX *and* LXXVII–CVI), 8vo. Berlin, 1824–'33.

Zweite Reihe. 30 vols. (I–XXX *and* CVII–CXXXVI). 1824–'43.

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[e.] Annalen der Physik und Chemie. Neue Folge. Unter Mitwirkung der physikalischen Gesellschaft in Berlin und insbesondere des Herrn H. Helmholtz. Herausgegeben von G. Wiedemann. 23 vols. (I–XXIII and CCXXXVII–CCLIX), 8vo. Leipzig, 1877–'84+

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Namen-Register zu Band I bis CL, Ergänzungsband I bis VI nebst Jubelband, und Sach-Register zu Band CXXI bis CL, Ergänzungsband V and VI nebst Jubelband, bearbeitet von W. Barentin, nebst einem Anhange von J. C. Poggendorff enthaltend Verzeichniss der verstorbenen Auctoren, und Zeitafel zu den Bänden. 8vo. Leipzig, 1875.

From 1877 *the* Annalen *are accompanied by:*

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JOURNAL DER RUSSISCHEN PHYSISCH-CHEMISCHEN GESELLSCHAFT. *See* Zhurnal russkova khimicheskova [etc.].

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111. JOURNAL FÜR TECHNISCHE UND ÖKONOMISCHE CHEMIE. Herausgegeben von Otto Linné Erdmann. 18 vols., 8vo. Leipzig, 1828–'33.

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Forschungen (Die neuesten) im Gebiete der technischen und ökonomischen Chemie.

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112. JOURNAL (THE) OF APPLIED CHEMISTRY. Devoted to chemistry as applied to the arts, manufactures, metallurgy, and agriculture. 10 vols., 4to. New York, Philadelphia, and Boston, 1866–'75.‖

113. JOURNAL (A) OF NATURAL PHILOSOPHY, CHEMISTRY, AND THE ARTS. Illustrated with engravings. By William Nicholson. 5 vols., 4to. London, 1797–1801.

Second series. 36 vols. (I–XXXVI), 8vo. London, 1802–'13.

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116. KRITISCHE ZEITSCHRIFT FÜR CHEMIE, PHYSIK UND MATHEMATIK. Herausgegeben in Heidelberg von A. Kekulé, F. Eisenlohr, G. Lewinstein, M. Cantor. 1 vol., 8vo. Erlangen, 1858.

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[**a.**] Kritische Zeitschrift für Chemie, Physik, Mathematik und die verwandten Wissenschaften und Disciplinen, als Pharmacie, Technologie, Agriculturchemie, Physik und Mineralogie. Unter Mitwirkung von Fachmännern, herausgegeben von E. Erlenmeyer und G. Lewinstein. 1 vol. (II), 8vo. Erlangen, 1859.

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[b.] Zeitschrift für Chemie und Pharmacie. Correspondenzblatt. Archiv und kritisches Journal für Chemie, Pharmacie und die verwandten Disciplinen. Unter Mitwirkung von Fachmännern, herausgegeben zu Heidelberg von E. Erlenmeyer und G. Lewinstein. 4 vols. (III–VII), 8vo. Erlangen [*later,* Heidelberg], 1860–'64.

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118. LABORATORY (THE). A monthly journal of the progress of chemistry, pharmacy, medicine, recreative science, and the useful arts. By J. F. Babcock. 2 vols., 4to. Boston, 1874–'76.

119. LABORATORY (THE). A weekly record of scientific research. 1 vol., 8vo. London, April to October, 1867.‖

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121. MAGAZIN FÜR APOTHEKER, CHEMISTEN UND MATERIALISTEN. Herausgegeben von Joh. Casp. Elwert. 3 parts, 8vo. Nürnberg, 1785–'87.

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[a.] Repertorium für Chemie, Pharmacie und Arzneimittelkunde. Herausgegeben von Joh. Casp. Elwert. 8vo. Hildesheim, 1790 [*second edition in* 1796].

122. MAGAZIN FÜR DIE HÖHERE NATURWISSENSCHAFT UND CHEMIE. 2 vols., 8vo. Tübingen, 1784–'87.

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124. MÉLANGES PHYSIQUES ET CHIMIQUES tirés du Bulletin physico-mathématique de l'Académie Impériale des sciences de St. Pétersbourg. 1846–'82. 12 vols., 8vo. St. Pétersbourg, 1854–'84+

125. Mémorial pratique de chimie manufacturière. Par Colin Mackensie. 3 vols., 8vo. Paris, 1824.

126. Memoirs of the Columbian Chemical Society of Philadelphia. 2 vols., 8vo. [Philadelphia], 1813, '14.

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128. Mittheilungen aus dem Gebiete der reinen und angewandten Chemie. Für Fachchemiker, Aerzte, Oeconomen, etc. Als Jahresbericht des Laboratoriums für 18**. Veröffentlicht von V. Kletzinsky. 4to. Wien, 1865, '66.

129. Mittheilungen aus dem Laboratorium der allgemeinen Chemie an der Kais. Kön. technischen Hochschule zu Brünn. 3 nos., 8vo. Wien, 1876.

Reprinted from Sitzungsberichte der K. Akademie der Wissenschaften.

130. Monatshefte für Chemie und verwandte Theile anderer Wissenschaften. Gesammelte Abhandlungen aus dem Sitzungsberichte der K. Akademie der Wissenschaften. 5 vols., 8vo. Wien, 1880–'84+

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131. Moniteur (Le) des produits chimiques, pour l'industrie, les sciences et les arts, et du matériel de ces industries. Publié par une Société de chimistes et d'industriels. Edmond Rousset, gérant. 14 (?) vols., 4to. Paris, 1871–'84+

132. Monthly (The) Magazine of Pharmacy, Chemistry, Medicine [etc.]. 5 (?) vols. London, 1876–'80+

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133. NATURHISTORISCHE UND CHEMISCH-TECHNISCHE NOTIZEN, nach den neuesten Erfahrungen zur Nutzanwendung für Gewerbe, Fabrikwesen und Landwirthschaft. 11 vols., 8vo. Berlin, 1854–'59.

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134. NORDISCHE BLÄTTER FÜR CHEMIE. Herausgegeben von Alex. Nic. Scherer. 1 vol., 8vo. Halle, 1817.

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[b.] Magazin für die neuesten Erfahrungen, Entdeckungen und Berichtungen im Gebiete der Pharmacie, mit Hinsicht auf physiologische Prüfung und practisch bewährte Anwendbarkeit der Heilmittel, vorzüglich neuentdeckter Arzneistoffe in der Therapie. Herausgegeben von G. F. Hänle [*from* 1829, *by* P. L. Geiger]. 36 vols., 8vo. Carlsruhe, 1823–'31.‖

From 1829–'31 *also under the title :* Magazin für Pharmacie und Experimental-Kritik. *United in* 1832 *with* Archiv des Apotheker-Vereins im nördlichen Teutschland, *forming the* Annalen der Pharmacie, *q. v.*

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136. PENNY MECHANIC AND CHEMIST. 8 vols. London, 1836–'42.

137. PHARMACEUTICAL (THE) TIMES. A journal of chemistry applied to the arts, agriculture, and manufactures. 3 vols., 4to. London, 1847, '48.

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[**a.**] Chemical (The) Times and Journal of Pharmacy, Manufactures [etc.]. [*Edited by* G. M. Mowbray.] 2 vols., 4to. London, 1848, '49.

138. PHARMACEUTISCHES CENTRALBLATT. [*Edited from* 1830–'38 *anonymously; from* 1840–'44, *by* A. Weinlig; 1845–'47, *by* R. Buchheim; 1848, '49, *by* W. Knop.] 20 vols., 8vo. Leipzig, 1830–'49.

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[**a.**] Chemisch-pharmaceutisches Centralblatt. Redacteur: W. Knop. 5 vols. (XXI–XXV), 8vo. Leipzig, 1850–'55.

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[**b.**] Chemisches Centralblatt. Repertorium für reine, pharmaceutische, physiologische und technische Chemie. Redaction: W. Knop. [*From* 1862, Red.: Rud. Arendt.] Neue Folge. 14 vols. (XXVI–XXXIX), 8vo. Leipzig, 1856–'69.

Dritte Folge. Redigirt von Rudolph Arendt. 15 vols. (XL–LIV), 8vo. Leipzig, 1870–'84+

General-Register zum chemischen Centralblatt, III Folge, Jahrgang I–XII. 1870–'81. Redigirt von Rud. Arendt. 1 vol., 8vo. Leipzig, 1882, '83.

139. PHARMACIST (THE) AND CHEMICAL RECORD. A monthly journal devoted to pharmacy, chemistry, and the collateral sciences. Published by the Chicago College of Pharmacy. Editor, N. Gray Bartlett; associate editor, Albert E. Ebert. [*From* vol. III, *edited by* E. H. Sargent.] 5 vols., 8vo. Chicago, 1868–'72.

Continued under the title:

[a.] Pharmacist (The). 6 vols. (VI–IX). Chicago, 1873–'78.

Continued under the title:

[b.] Pharmacist (The) and Chemist. Published by the Chicago College of Pharmacy. [*Conducted by* Robert H. Cowdrey.] 6 vols. (XII–XVII). Chicago, 1879–'84+

PHILADELPHIA.
See Memoirs of the Columbian Chemical Society.

140. PHILOSOPHICAL (THE) MAGAZINE. Comprehending the various branches of science, the liberal and fine arts, agriculture, manufactures, and commerce. By Alexander Tilloch. 42 vols., 8vo. London, 1798–1813.

United in 1814 *with the* Journal of Natural Philosophy, by William Nicholson, *and continued under the title:*

[a.] Philosophical (The) Magazine and Journal. Comprehending the various branches of science, the liberal and the fine arts, geology, agriculture, manufactures, and commerce. By Alexander Tilloch [*from* 1824, *by* Alexander Tilloch *and* Richard Taylor]. 26 vols. (XLIII–LXVIII), 8vo. London, 1814–'26.

United in 1827 *with the* Annals of Philosophy, or Magazine of Chemistry, by Richard Phillips, *and continued under the title:*

[b.] Philosophical (The) Magazine; or, Annals of Chemistry, Mathematics, Astronomy, Natural History, and General Science. New and united series of the Philosophical Magazine and Annals of Philosophy. By Richard Taylor and Richard Phillips. 11 vols. (I–XI), 8vo. London, 1827–'32.

United in 1832 *with the* Edinburgh Journal of Science, by David Brewster, *and continued under the title:*

[c.] London and Edinburgh Philosophical Magazine and Journal of Science. Conducted by David Brewster, Richard Taylor, and Richard Phillips. New and united series of the Philosophical Magazine and Journal of Science. 37 vols. (I–XXXVII), 8vo. London. 1832–'50.

Continued under the title:

[d.] London, Edinburgh, and Dublin Philosophical Magazine and Journal of Science. Conducted by David Brewster, Richard Taylor, Richard Phillips, Robert Kane, and William Francis. Fourth series. 50 vols. (I–L), 8vo. London, 1851–'75.

Fifth series. Edited by R. Kane, W. Thomson, and W. Francis. 18 vols. (I–XVIII), 8vo. London, 1876–'84+

141. PIRIA (IL). Giornale di scienze chimiche. Napoli, 1875.

POGGENDORFF'S ANNALEN.
See Journal der Physik.

POLLI, GIOVANNI.
See Giornale di farmacia, chimica e scienze accessorie.

POPULAR SCIENCE NEWS.
See Boston Journal of Chemistry.

POST, JULIUS.
See Zeitschrift für das chemische Grossgewerbe.

142. PROCEEDINGS OF THE AMERICAN CHEMICAL SOCIETY. 1876–'78. 1 vol., 8vo. New York, 1877.

Continued under the title:

[a.] Journal of the American Chemical Society. 6 vols., 8vo. New York. 1879–'84+

143. PROCEEDINGS OF THE CHEMICAL SOCIETY OF LONDON. 1841–'43. 1 vol., 8vo. London, 1843.

[a.] Memoirs and Proceedings of the Chemical Society of London. 1841–'48. 3 vols., 8vo. London, 1843–'48.

[b.] Quarterly Journal of the Chemical Society of London. 14 vols. (I–XIV), 8vo. London, 1849–'62.

Continued under the title:

Journal of the Chemical Society of London. 1 vol. (XV), 8vo. London, 1862.

Second series. 14 vols. (I–XIV). London, 1863–'76.

Third series. 2 vols. (I–II). London, 1876.

Fourth series. 16 vols. (I–XVI). London, 1877–'84.

PUBLIC ANALYSTS, SOCIETY OF.
See Analyst (The).

QUESNEVILLE, DR.
See Revue scientifique et industrielle.

144. RACCOLTA FISICO-CHIMICA ITALIANA. Ossia collezione di memorie originali edite ed inedite di fisici, chimici e naturalisti italiani dell' Ab. Francesco Zantedeschi. 3 vols., roy. 8vo. Venezia, 1846–'48.

Followed by:

Annali di fisica, dell' Abbate F. C. Zantedeschi. 1 vol., roy. 8vo. Padova, 1849, '50.

145. RAPPORT ANNUEL SUR LES PROGRÈS DES SCIENCES PHYSIQUES ET CHIMIQUES présenté - - - à l'académie royale des sciences de Stockholm par J. Berzelius. Traduit du Suédois par Ph. Plantamour. 4 vols., 8vo. Paris, 1841–'44.

Continued under the title:

[**a.**] Rapport annuel sur les progrès de la chimie, présenté - - - à l'académie royale des sciences de Stockholm par J. Berzelius. Traduit du Suédois par Ph. Plantamour. 2 vols., 8vo. Paris, 1845, '46.

Cf. Annuaire des sciences chimiques ; *also* Årsberättelse om Framstegen i Physik och Chemi ; *also* Jahresbericht über die Fortschritte der physischen Wissenschaften.

146. RECHERCHES PHYSICO-CHIMIQUES. 3 nos., 4to. Amsterdam, 1792–'94.

147. RECUEIL DES TRAVAUX CHIMIQUES DES PAYS-BAS, Par W. A. van Dorp, A. P. N. Franchimont, S. Hooge-Werff, E. Mulder et A. C. Oudemans, Jr. 3 vols., Roy. 8vo. Leide, 1882–'84+

REMSEN, IRA.
See American Chemical Journal.

148. Répertoire de chimie, de physique, et d'applications aux arts. Contenant les traductions ou extraits des travaux qui se publient sur ces matières dans les pays étrangers, et de plus un résumé rapide des mémoires parus en France. Rédigé par Ch. Martin, sous la direction de Gaultier de Claubry. 1 vol., 8vo. Paris, 1837.

Continued under the title:

[**a.**] Répertoire de chimie scientifique et industrielle. Contenant les traductions ou extraits des travaux qui se publient sur cette matière dans les pays étrangers, et de plus un resumé des mémoires les plus intéressants parus en France. Rédigé par Ch. Martin, sous la direction de Gaultier de Claubry. 4 vols., 8vo. Paris, 1837, '38.

Continued under the title:

[**b.**] Répertoire de chimie. Mémorial des travaux étrangers. Rédigé par Gaultier de Claubry et Ch. Gerhardt. Deuxième série. 1 vol., 8vo. Paris, 1839.‖

149. [**A.**] Répertoire de chimie pure et appliquée. Compte rendu des progrès de la chimie pure en France et à l'étranger. Par Adolphe Wurtz, avec la collaboration de Chas. Friedel, Girard, LeBlanc, et A. Riche, pour la France; Williamson, pour l'Angleterre; Lieben, pour l'Allemagne; L. Schischkoff, pour la Russie; Rosing, pour les pays Skandinaves; Frapolli, pour l'Italie. 5 vols., 8vo. Paris, 1858–'63.

Simultaneously with the above a section devoted to applied chemistry was published under the title:

[**B.**] Répertoire de chimie pure et appliquée. Compte rendu des applications de la chimie en France et à l'étranger. Par Ch. Barreswil, avec la collaboration de Daniel Koechlin, Hervé Mangon, Em. Kopp, de Clermont, pour la France; Knapp, Boettger, Sobrero, Rosing, Boutlerow, pour l'étranger. 5 vols., 8vo. Paris, 1858–'63.

In 1864 [A] *and* [B] *were united and continued under the title:*

[**a.**] Bulletin de la Société chimique de Paris. Comprenant le compte rendu des travaux de la Société et l'analyse des mémoires de chimie pure et appliquée publiés en France et à l'étranger, par Ch. Barreswil, J. Bouis, Ch. Friedel, E. Kopp, F. LeBlanc, A. Scheurer-Kestner et Ad. Wurtz, avec la collaboration de C. G. Foster, A. Girard, A. Lieben, A. Riche, A. Rosing, Thoyot, A. Vée et E. Willm. Nouvelle série. 42 vols., 8vo. 1864–'84+

150. RÉPERTOIRE DE PHARMACIE, DE CHIMIE, DE PHYSIQUE, D'HYGIENE PUBLIQUE, de la médecine légale et de thérapeutique ; réimpression générale des ouvrages périodiques publiés en France sur ces sciences. 1 vol., 8vo. Bruxelles, 1842.

151. RÉPERTOIRE DE PHARMACIE. Recueil pratique. Rédigé par A. Lartigue. [*From* vol. III, *by* Bouchardat.] 29 vols., 8vo. Paris, 1844–'73.

Nouvelle série. 3 vols., 8vo. Paris, 1874–'76.

United with the Journal de chimie médicale *and continued under the title :*

[**a.**] Répertoire de pharmacie et Journal de chimie médicale réunis. Dirigé par Eug. Lebaigue. 14 vols., 8vo. Paris, 1876–'84+

Cf. Journal de chimie médicale.

152. REPERTORIUM DER ANALYTISCHEN CHEMIE für Handel, Gewerbe und öffentliche Gesundheitspflege. Redigirt von Skalweit. 8vo. Hannover, 1881+

153. REPERTORIUM DER CHEMIE UND PHARMACIE. Herausgegeben von Swittau. 8vo. St. Petersburg, 1837 [+?]

REPERTORIUM FÜR CHEMIE. Elwert.
See Magazin für Apotheker.

154. REPERTORIUM FÜR DIE PHARMACIE. Angefangen von Adolph Ferdinand Gehlen und fortgesetzt in Verbindung mit C. F. Bucholz, Rink und Anderen, von Johann Andreas Buchner. [*From* vol. V, unter Mitwirkung des

Apotheker-Vereins in Baiern, herausgegeben von Johann Andreas Buchner.] 50 vols., 12mo. Nürnberg, 1815–'34.

Zweite Reihe. 50 vols., 12mo. Nürnberg, 1835–'48.

Dritte Reihe. 10 vols., 12mo. Nürnberg, 1849–'51.

Continued under the title:

[**a.**] Repertorium (Neues) für Pharmacie. Unter Mitwirkung von Alb. Frickhinger, C. F. Hänle, J. E. Herberger, X. Landerer, Th. W. Ch. Martius, W. Mittenheimer, Friedrich Mohr, Max Pettenkofer, A. Schnizlein, F. L. Winkler, herausgegeben von J. A. Buchner. 25 vols., 12mo. Nürnberg, 1852–'76.||

Ergänzungsband. 1 vol., 12mo. Nürnberg. 1816.

155. Repertorium für organische Chemie. Herausgegeben von C. Löwig. 3 vols., 8vo. Zürich, 1841–'43.||

Repertorium für Pharmacie. Buchner.
See Repertorium für die Pharmacie.

156. Repertorium für Pharmacie und praktische Chemie in Russland: oder, Zusammenstellung des Wichtigsten und Wissenswerthesten aus den neuesten Entdeckungen im Gebiete der Pharmacie und Chemie mit vorzüglicher Rücksicht auf das russische Reich. Red.: C. Gauger. 8vo. St. Petersburg, 1842.

157. Revue scientifique et industrielle des faits les plus utiles et les plus curieux observés dans la médecine, l'hygiène, la physique, la chimie, la pharmacie, l'économie rurale et domestique, l'industrie nationale et étrangère. Sous la direction de Quesneville. 16 vols. (I–XVI), 8vo. Paris, 1840–'44.

Deuxième série. 15 vols. (I–XV), 8vo. 1844–'47.

Troisième série. 9 vols. (I–IX), 8vo. 1848–'51.

Quatrième série. 1 vol., 8vo. 1852.

Followed by:

[**a.**] Moniteur (Le) scientifique du chimiste et du manufacturier. Livre-Journal de chimie appliqué aux arts et à l'industrie. Spécialement consacré à la chimie générale pure et appliquée, par Quesneville. 5 vols. (I–V), 4to. Paris, 1857–'63.

Continued under the title :

[b.] Moniteur (Le) scientifique. Journal des sciences pures et appliquées. Deuxième série. 7 vols. (VI–XII), 4to. Paris, 1864–'70.

Continued under the title :

(c.) Moniteur scientifique—Quesneville. Journal des sciences pures et appliquées, compte rendu des académies et sociétés savantes et revue des progrès accomplis dans les sciences mathématiques, physiques et naturelles. Photographie, chimie, pharmacie, médecine, revue des inventions nouvelles et industrie manufacturière des arts chimiques. Journal fondé et dirigé par Quesneville. Troisième série. 14 vols., 4to. Paris, 1871–'84+

158. Revue des industries chimiques et agricoles. 7 vols., 8vo. Paris, 1878–'84+

Richter, J. B.
See Ueber die neueren Gegenstände in der Chemie.

Rozier's Journal.
See Introduction aux observations sur la physique [etc.].

159. Rivista di chimica, medica e farmaceutica, tossicologia, farmacologia e terapia. Diretta da P. Albertoni e J. Guareschi. 1 vol. Torino, 1883+

Šafařik, V.
See Časopis chemiků českých [b.] ; *also* Zprávy spolku chemiků českých.

160. Sammlung auserlesener Abhandlungen über die interessantesten Gegenstände der Chemie. Aus dem lateinischen mit einigen Anmerkungen begleitet. Redigirt von Hochheimer. 1 vol., 8vo. Leipzig, 1793.

161. Scheikundige bibliotheek, waarin de voornaamste nieuwe ontdekkingen en verbeteringen, welke in der scheikunde in uns vaterland, doch wel meest in andre landen van tijd tot tijd gedaan worden, kortelijk worden voorgetragen. Door een gezelschap van beminaaren dezer wetenschap. 2 vols., 8vo. Delft, 1790–'98.

Continued under the title:

[**a.**] Scheikundige (Nieuwe) bibliotheek. 3 vols., 8vo. Amsterdam, 1799-1802.

162. SCHEIKUNDIGE BIJDRAGEN. — vols. Amsterdam, 1867.

163. SCHEIKUNDIGE ONDERZOEKINGEN, GEDAAN IN HET LABORATORIUM DER UTRECHTSCHE HOOGESCHOOL. Uitgegeven door G. J. Mulder. 6 vols., 4to. Rotterdam, 1845–'52.

Followed by:

[**a.**] Scheikundige verhandelingen en onderzoekingen uitgegeven door G. J. Mulder. 3 vols., 8vo. Rotterdam, 1857–'64.

Followed by:

[**b.**] Scheikundige aanteekeningen uitgegeven door G. J. Mulder. 1 vol., 8vo. Utrecht, 1865–'67.

Followed by:

[**c.**] Scheikundige onderzoekingen, gedaan in het physiologisch laboratorium der Utrechtsche Hoogeschool. Nieuwe serie. 3 vols., 8vo. Rotterdam, 1867–'71.

Derde serie. 4 vols., 8vo. 1871–'76 [+ ?]

SCHEIKUNDIGE VERHANDELINGEN. Rotterdam.
See Scheikundige onderzoekingen.

SCHERER, ALEX. NIC.
See Allgemeine nordische Annalen der Chemie ; *also* Allgemeines Journal der Chemie ; *also* Archiv für die theoretische Chemie; *also* Nordische Blätter für Chemie.

164. SCHOOL (THE) OF MINES QUARTERLY. Published by the chemical and engineering societies of the School of Mines, Columbia College, New York. 6 vols., 8vo. New York, 1879–'84+

SELMI, FRANCESCO.
See Annuario chimico italiano.

SCHWEIGGER, J. S. C.
See Allgemeines Journal der Chemie [*c.*].

SEMBENINI, G. B.
See Annuario delle scienze chimiche [etc.]; *also* Gazzetta eclettica di chimica tecnologica; *also* Gazzetta eclettica di farmacia e chimica medica.

SIEBEL, J. E.
See Chemical Review and Journal.

SIMON, FRANZ.
See Beiträge zur physiologischen und pathologischen Chemie.

SKALWEIT'S REPERTORIUM.
See Repertorium der analytischen Chemie.

SOCIETIES, CHEMICAL.

American, see Proceedings of the American Chemical Society.

Chemical Industry, see Journal of the Society of Chemical Industry.

Columbian, see Memoirs of the Columbian Chemical Society.

French, see Répertoire de chimie pure et appliquée.

German, see Berichte der deutschen chemischen Gesellschaft.

London, see Proceedings of the Chemical Society of London.

Public Analysts, see Analyst (The).

Russian, see Zhurnal russkova khimicheskova [etc.].

School of Mines, see School of Mines Quarterly.

STAEDEL, W.
See Jahresbericht über die Fortschritte auf dem Gebiete der reinen Chemie.

STÖCKHARDT, J. A.
See Chemische Ackersmann.

ST. PETERSBURG.
See Zhurnal russkova khimicheskova [etc.].

SVANBERG, L. F.
See Årsberättelse om Framstegen i Physik och Chemi [*b.*].

SWITTAU'S REPERTORIUM.
See Repertorium der Chemie und Pharmacie.

TABLEAU DU TRAVAIL ANNUEL (etc.).
See Introduction aux observations sur la physique [etc.].

TAYLOR, RICHARD.
See Philosophical Magazine.

165. TASCHENBUCH FÜR SCHEIDEKÜNSTLER UND APOTHEKER. Herausgegeben von Ch. F. Bucholz. 8vo. Weimar, 1803-'19.

Cf. Almanach für Scheidekünstler und Apotheker.

166. TECHNISCH-CHEMISCHER KALENDER FÜR OESTERREICH-UNGARN. Jahrbuch und Notizbuch für den theoretischen und praktischen Chemiker, Fabrikanten, Bierbrauer, Branntweinbrenner, Zuckerfabrikanten. Herausgegeben von Paul Bennewitz. 2 vols., 16mo. Wien, 1875, '76.‖

167. TECHNISCH-CHEMISCHES GEWERBEBLATT. Gesammelte Vorschriften und Erfahrungen in der technischen Chemie. Zum Nutzen der Gewerbtreibenden und Fabrikanten, herausgegeben von L. F. Denzer. 1 vol., 8vo. Berlin, 1849. '50.‖

168. TECHNISCH-CHEMISCHES JAHRBUCH. Herausgegeben von Rudolph Biedermann. 5 vols., 16mo. Berlin, 1880–'84+

This forms the second part of the Chemiker-Kalender. Herausgegeben von Rudolph Biedermann. 5 vols., 16mo. Berlin, 1880–'84+

169. TEKNO-KEMISK JOURNAL. P. O. Almström. Stockholm, 1847–'48.

THOMSEN, A. (AND J.).
See Tidsskrift for Physik og Chemi.

THOMSON'S ANNALS.
See Annals of Philosophy.

THUDICHUM, J. L. W.
See Annals of Chemical Medicine.

170. TIDSSKRIFT FOR ANVENDT CHEMI, for fabrikanter, chemikere, pharmaceuter og handlende. Udgivet af T. Holm og A. E. M. Schleisner. 1 vol., 8vo. Kjøbenhavn, 1869, '70.

171. TIDSSKRIFT FOR PHYSIK OG CHEMI SAMT DISSE VIDENSKABERS ANVENDELSE. Udgivet af A. og J. Thomsen. 9 vols., 8vo. Kjøbenhavn, 1862–'70.
Anden Række. 12 vols., 8vo. 1871–'82+

172. TIJDSCHRIFT VOOR WETENSCHAPPELIJKE PHARMACIE, benevens mededeelingen over chemie, pharmacie en pharmacognosie van het planten-, dieren- en delfstoffelijk rijk. Geredigeerd door P. J. Haaxmann. 5 vols., 8vo. Voorburg, 1849–'53.

Tweede serie. 5 vols., 8vo. 's Gravenhage, 1854–'58.

Continued under the title :

[**a**.] Tijdschrift voor wetenschappelijke pharmacie. Geredigeerd door P. J. Haaxmann, bevattende de mededeelingen der Nederlandsche maatschappij ter bevordering der pharmacie. Derde serie. 6 vols., 8vo. Gorinchem, 1859–'64.

Nieuwe serie. 9 vols., 8vo. Gorinchem, 1865–'73.

Tilloch, Alex.
See Philosophical Magazine.

173. Toegepaste scheikunde. Tweemaandelijksch tijdschrift, bevattende mededeelingen uit het gebied der toegepaste scheikunde voor het algemeen. Onder redactie van R. J. Opwyrda. 5 vols., 8vo. Vlaardingen, 1865–'69.

Nieuwe serie. 4 vols., 8vo. 1870–'75.

Continued under the title;

[**a**.] Maandblad voor toegepaste scheikunde, bevattende mededeelingen uit het gebied der toegepaste scheikunde voor het algemeen. Redacteur: R. J. Opwyrda. Tredie serie. 5 vols., 8vo. Amsterdam, 1876–'80 (+?).

Trier, S. M.
See Archiv for Pharmaci.

Trommsdorff, J. B.
See Allgemeine chemische Bibliothek ; *also* Almanach für Scheidekünstler [*b*] ; *also* Annalen der Pharmacie ; *also* Journal der Pharmacie für Aerzte und Apotheker.

Trommsdorff's Taschenbuch für Scheidekünstler.
See Almanach für Scheidekünstler.

174. Ueber die neueren Gegenstände in der Chemie. Herausgegeben von J. B. Richter. 11 parts, 8vo. Breslau, Hirschberg und Lissa, 1791–1802.‖

175. Untersuchungen aus Liebig's Laboratorium. 1 vol., 8vo. Wien, 1872.

176. Vierteljahresschrift für technische Chemie, landwirthschaftliche Gewerbe, Fabrikwesen und Gewerbtreibende überhaupt. Unter Mitwirkung mehrerer Gelehrten, Fabrikanten und Techniker, herausgegeben von Wilibad Artus. 10 vols., 8vo. Quedlinburg, 1859–'69.‖

Wagner's Jahresbericht.
See Jahresbericht über die Fortschritte der chemischen Technologie.

Wasserberg, F. A. X.
See Beiträge zur Chemie.

Watt, Charles (and John).
See Chemist (The).

Westrumb, J. F.
See Kleine physikalisch-chemische Abhandlungen.

Wiedemann's Annalen.
See Journal der Physik [*e*].

Wigner, G. W.
See Analyst (The).

Wöhler, Fr.
See Annalen der Pharmacie [*b*].

Wood (Charles H.), and Sharp (Charles).
See Chemist's Desk Companion ; *also* Year-book of Pharmacy.

Wurtz, Adolphe.
See Répertoire de chimie pure et appliquée.

177. Year-book of Pharmacy. A practical summary of researches in pharmacy, materia medica, and pharmaceutical chemistry, [*in* 1881, and transactions of the Pharmaceutical Conference]. Edited by Charles H. Wood and Charles Sharp. 18 vols., 8vo. London, 1865–'82+

Cf. Chemist's (The) Desk Companion.

Zantedeschi, Francesco.
See Giornale fisico-chimico italiano ; *also* Raccolta fisico-chimica italiana.

178. Zeitschrift für analytische Chemie. Herausgegeben von C. Remigius Fresenius. 23 vols., 8vo. Wiesbaden, 1862–'84.

Autoren- und Sach-Register zu den Bänden I–X (1862–'71). 1 vol., 8vo. Wiesbaden, 1872.

Autoren- und Sach-Register zu den Bänden XI–XX (1872–'81). Bearbeitet von Heinr. Fresenius, unter Mitwirkung von Wilh. Lenz. 8vo. Wiesbaden, 1882.

Zeitschrift für Chemie und Pharmacie.
See Kritische Zeitschrift für Chemie.

179. Zeitschrift für das chemische Grossgewerbe. Kurzer Bericht über die Fortschritte der chemischen Grossindustrie. Unter Mitwirkung von angesehenen Technologen und Technikern, sowie von F. Frerichs, J. Landgraf, K. Polstorff, P. Wagner, H. Wiesinger, F. Wunderlich, herausgegeben von Jul. Post. 7 vols., 8vo. Berlin, 1876–'82.‖

180. Zeitschrift für physiologische Chemie. Unter Mitwirkung von E. Baumann, Gähtgens, Hüfner, [etc.], herausgegeben von F. Hoppe-Seyler. 8 vols., 8vo. Strassburg, 1877–'84+

181. *Zhurnal russkova khimicheskova i fizicheskova obschetsva pri St. Peterburgskom Universitetye. 16 vols., 8vo. St. Peterburg, 1869–'84+

182. Zprávy spolku chemiků českých. Rediguje: V. Šafařik. 2 vols., 8vo. v Praze, 1872–'76 [+ ?]

Cf. Časopis chemiků českých.

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* Attempts to transliterate Russian are very unsatisfactory; instead of rendering the title phonetically, as above, it may be given literally thus:—Journal russkago khimicheskago i fizicheskago obschetsva, [etc.].

GEOGRAPHICAL INDEX.

The numbers refer to the titles of publications.

CORRECTIONS.

Title 66, *for* Ueberisichtlich *read* Uebersichtlich.
" 74, line 1, *for* ä *read* à.
Page 188, line 1, *for* Berlinische *read* Berlinisches.
Title 106[*a*], *for* serie *read* série.

VII.—*Descriptions of some peculiar screw-like Fossils from the Chemung Rocks.*

BY J. S. NEWBERRY.

Read Dec. 10th, 1883.

In the sandstones of the Chemung Group in Northern Pennsylvania and Southern New York, have been found a number of cylindrical or fusiform bodies, traversed by spiral raised ridges, which have been something of a puzzle to those who have collected them. At first sight, they would seem to bear a close relationship to some species of *Spirangium*, particularly *Sp. Quenstedti*, Sch. (*Palæoxyris.* Quenstedt, Handbuch d. Petrefacten, Tab. LXXXII, Fig. 9), and *Sp. Gilewii*, Romanowski, (Geol. Turkestan, p. 135, Taf. 23, Fig. 3).

But in these, as in all the other species of *Spirangium* described, the fusiform body is traversed by six or more spiral raised lines, instead of two as in the specimens under consideration.

The geological horizons of these fossils are also different, *Spirangium* ranging from the Coal-measures to the Wealden, while our screw-like casts, to which the name *Spiraxis* is now given, are confined, so far as yet known, to the Chemung.

The resemblance between some of the species of *Spiraxis* and the species of *Spirangium* enumerated above, is so striking that it is difficult to resist the conviction that they are of similar character and somewhat closely related. *Spirangium* has been generally considered as a fruit of some kind, and the first species noted was described by Brongniart under the name of *Palæoxyris regularis*, (Ann. Sc. Nat., 1re Sér., Vol. XV, p. 456) from a conviction that it was the fruit of a plant allied to *Xyris*. Ettingshausen has also suggested that *Spirangium* is the fruit of an extinct plant related to the living *Bromelia*, and so has called it *Palæobromelia*, (Abhandl. d. K. K. Geol. Reichsanstalt, I, 3, p. 3). These views have not been generally accepted, however, and no satisfactory conclusion has been reached in regard to the botanical relations of *Spirangium*.

The first impression of the writer in examining the fossils now under consideration, was that they were the stems of algae. They are mere casts, all traces of the original structure having disappeared, as is generally the case with fossilized sea-weeds. It is also true that in the same and adjacent formations the remains of fucoids with spiral fronds, *Spirophyton*, are not uncommon. The stems of *Spirophyton*, however, are never found stripped of the fronds, and nothing which resembles the fossils before us has been detected in a careful examination of the upper extremity of the stems of *Spirophyton* The Archimedes Screw, *Retepora Archimedes*, has a great resemblance in form to these fossils, but that is a calcareous animal organism, of which the structure is very easily made out, for the salient revolving ridges which it bears are only the bases from which the expanded fronds of a Bryozöon have been torn away. On the contrary, *Spiraxis* is a simple cast, no calcareous matter remaining, as would certainly be the case if it represented a coral or mollusk. The original substance has entirely disappeared, and yet it had sufficient solidity to form a defined mould in the sand where it was buried ; and when the organic tissue disappeared, as it did completely, the cavity was filled by infiltration, and a perfect cast was thus produced. Nothing is more common than to find the casts of sea-weeds formed in this way ; but it is also true that sponges are sometimes fossilized in a similar manner. The group of *Dictyospongia*, formerly considered sea-weeds, and described under the name of *Dictyophyton*, generally exhibit the same absence of organic structure, and are simply casts in the sandstone ; but they have been referred to of late by all writers as sponges, and in some instances slight traces of original tissue have been preserved, which place their true character beyond a doubt. Among the sponges there are none known to the writer which exhibit anything like the regular spiral structure which is characteristic of our fossils ; but a tendency to a spiral mode of growth appears in some sponges, and is very distinctly seen in *Hyalonema*, and in *Siphonocœlia*, Roemer, (*Stachyspongia*, Zittell). No positive evidence can therefore yet be adduced to satisfy the questions which have been asked in regard to the biological relations of these singular "sandstone screws" from the Chemung. The interior, in all cases yet observed, is composed of sand, with sometimes small quartz pebbles. These indicate that the organic tissue was soft, and early disappeared, leaving a cavity which was filled in with sand and fine gravel introduced through an orifice at one extremity. The upper end is conical and, in several specimens which I possess, complete ; but the lower end is broken off, and the nature of the part removed remains unknown. It is possible that we have nearly the entire organism, and that it was fusiform with two conical extremities. This is, however, less probable than that it continued below in some sort of a stem that served as a support. Doubtless future discoveries will solve this problem.

The specimens in my possession may be concisely described as follows :

SPIRAXIS. (nov. gen.)

Body cylindrical, or sub-fusiform, somewhat abruptly conical above, more gradually tapering below ; surface traversed by two parallel revolving spiral ridges, in some species closely approximated, in others separated by intervals half as wide as the diameter ; no traces of internal structure or distinct surface-markings visible.

Two species are known to me, viz.,

1. Spiraxis major, n. sp.

PL. XVIII, FIG. 1.

Body cylindrical, about one inch in diameter, terminating above in a conical summit, traversed by two strong spiral revolving ridges which cross the axis at an angle of about 45°. These ridges are flattened or sulcated and somewhat roughened, as though for the attachment of some frond-like appendage. They are separated by broad, deep and smooth furrows about three times the width of the flattened summit of the ridge ; the surface of the furrow is smooth or obscurely granulated.

Only a single specimen of this species is known, but this is remarkably well preserved. It is about 7 inches in length by one in diameter. The summit is complete, but it is broken off below, leaving the entire form uncertain. It apparently shows a tendency to narrow downward, and the spiral ridges are there somewhat more widely separated, as though tending to open and become obsolete.

Formation and locality, Chemung Rocks, Southern New York.

2. Spiraxis Randalli, n. sp.

PL. XVIII, FIGS. 2, 3.

Body fusiform, three or four inches in length by six to eight lines in diameter ; surface marked by two revolving and closely approximated ridges, which below are broad and flattened or rounded, and separated by narrow furrows, above acute and narrow, separated by broader furrows.

From *S. major* this species may be distinguished by its smaller size, its somewhat curved or sinuous form, and the closer approximation of the raised ridges, which are also more flattened and relatively broader.

Formation and locality, Chemung Group, Warren, Penna., where it was first obtained by Mr. F. A. Randall, to whom it is dedicated.

Since the above descriptions were written, Prof. James Hall, of Albany, and Prof. H. S. Williams, of Cornell University, have kindly sent to me for examination the considerable number of specimens of *Spiraxis* which they have obtained from the Chemung rocks of Northern Pennsylvania and Southern New York. Of these, all those received from Prof. Hall represent the species *S. Randalli;* none are more complete than those now figured, and none exhibit characters which throw any light on the biological relations of these fossils. Among the specimens sent by Prof. Williams, is one larger than the others, much curved and flattened and having the spiral ridges relatively broad and flat. It approaches most nearly to *S. Randalli* and may be only a phase of that species, but more material will be required before this question can be settled.

It is to be hoped that by the publication of this notice of these singular organisms, the attention of those who are making collections from the Chemung rocks will be specially directed to them, and that by the discovery of specimens which are better preserved, or by tracing their connections or relations as they lie in the rock, their true nature may be determined.

The originals of the figures now given are in the Geological Cabinet of the School of Mines of Columbia College.

VIII.—*Note on the Temperature of Incandescence, and its bearing upon Solar Physics.*

BY WALLACE GOOLD LEVISON.

Read Feb. 2d, 1885.

It has long been assumed that all solid and liquid substances begin to emit light, or become visibly incandescent, at a common temperature which has been fixed at

635°	by	Sir Isaac Newton.
812°	"	Sir Humphrey Davy.
947°	"	Mr. Wedgewood.
980°	"	Mr. Daniell,—and
977°	"	Dr. J. W. Draper.

The last figure was obtained by Prof. Draper as the result of a series of experiments which he considered sufficiently conclu-clusive to authorize the suggestion of three laws[1] :—First, that all substances become visibly incandescent at the same temperature ;—second, that this temperature is 977° ;—third, that the length of spectrum of an incandescent solid or liquid substance is a measure of its temperature. Now, in view of the following facts, it would seem that these laws must be modified, or at least restricted in application to opaque solids and liquids only.

When a rod of hard German glass (potash and lime silicate) and a rod of soft glass (alkali or lead silicate) are held side by side in the flame of a Bunsen burner, the soft glass rod soon becomes red-hot or visibly incandescent, while the hard glass is but faintly luminous ; and even when they have equally acquired the temperature of the flame, about 2.350 C., [2]the hard glass has

1 Draper. Dr. J. W.. on the radiation of red-hot bodies and the production of light by heat. Am. Jour. Sci., 2 Series. Vol. IV. 1847. London, Edinburg and Dublin Phil. Mag.. May, 1877. Harpers' Monthly. No. 322. Memoirs N. Y.. 1878 8vo. Astor, 446 D. 1st Memoir.

2 Roscoe, on Spectrum Analysis, p 51.

made but little progress toward incandescence compared with the other. If a number of little discs of platinum are arranged in a figure within a hard glass combustion-tube, and while the tube is highly heated over a blast lamp are imbedded in the glass, and the tube then allowed to cool gradually in a dark room,—long after the tube has become invisible the pieces of platinum may be distinctly seen.

Again, take a hard glass combustion-tube and within its middle third arrange a series of pieces of platinum, copper, iron, lead, asbestos, pumice, and soft and hard glass, and heat them in a combustion-furnace to bright redness. Then, partly closing the ends of the tube with the finger, to prevent a current of cold air through it, carry it into a perfectly dark room and watch it cool. The tube soon becomes absolutely invisible, but long afterward the objects within it, with the exception of the pieces of hard glass, may be clearly distinguished. That the continued incandescence of the contained objects within the tube is not due to difference in rapidity of cooling, or other variability of condition, is it seems to me conclusively shown by the fact that the enclosed pieces of hard glass become invisible at the same time as the tube itself.

The visibility of the heated contents of a combustion-tube in the furnace, is an instance of this phenomenon, that is perfectly familiar to organic analysts.

These experiments were suggested to me by one which I tried over two years ago for a gentleman who conceived the idea that spirals or baskets made of threads of pure silica might be advantageously employed instead of platinum wire spirals for suspending in hydrogen, water-gas, or other non-luminous gas-flames, to produce incandescent lights. I found that by taking two angular fragments of amorphous quartz in separate pincers, heating their pointed ends in an oxyhydrogen flame, touching them together where fused and suddenly drawing them apart,—threads of silica as much as two decimeters long may be made. No crystallized quartz I have tried will answer, because it decrepitates too violently; and a jet of pure hydrogen and oxygen seems necessary, because the common jet of coal-gas and oxygen appears to produce insufficient heat to well fuse the silica. I found however that when such a thread of silica was held side by side with a platinum wire, of the same diameter, in the flame of a Bunsen burner, it could not be rendered incandescent, though the platinum wire glowed brightly. Examination with a spectroscope showed that the silica thread gave practically no spectrum, and consequently emitted no light whatever, except at points where some opaque foreign particle might be entangled within it. Bearing as it does upon several applications of quartz in the form of lenses and prisms, and upon various diathermic considerations, this experiment evidently suggests the desirability of an examination of the relation to radiant energy of quartz which has been fused and which can therefore no longer contain microscopic water-cavities. Professor C. A. Young, who saw it at a meeting of the American Astronomical Society, in June, 1883, regarded it as a very pretty experiment and probably a consequence of Kirchoff's law.

As is usually the case when once a general principle is revealed to us, evidences of it are easily recognized in the most familiar instances, and the phenomena of this principle are presented to us in all varieties by the ordinary blow-pipe beads.

If a bead of borax or microcosmic salt be heated and allowed to cool. the bead itself at any moderate temperature is hardly visible; but even after it has cooled in a dark room until quite invisible, the platinum wire ring still remains red-hot, and may be distinctly seen. A bead of carbonate of soda behaves differently. When very hot, in a dark room it appears almost non-luminous, even though the ring of platinum wire glows quite hot, but at the moment of solidifying it suddenly incandesces with a red heat, and it and the wire then degrade together in luminosity until they become, at the same instant, invisible.

Upon the surface of, or within such a bead, of borax or carbonate of soda, while hot and transparent, a foreign particle floats about red-hot; and under a considerable depth of certain melted fluxes, I have seen a button of pure silver, at the bottom of a crucible, almost as clearly as it could be seen through so much cold glass.

Another interesting instance involving this principle occurs in the case of melted gold, which is less luminous at a certain temperature. than after it has cooled down to the point at which it solidifies, when it suddenly emits a brilliant light.

From these considerations it seems to me we may fairly conclude, not that silicates, borates, phosphates and similar hyaline compounds are absolutely non-luminous at very high temperatures, but even though not many such compounds have been carefully examined, that a substance which remains transparent will be far less luminous at a high temperature than one which becomes opaque.

Sir J. F. W. Herschel, in the text of his Outlines of Astronomy, like many other observers, describes the physical appearance of the sun as most nearly resembling a fused liquid mass, covered by a luminous envelope; and while he argues for a very high temperature in the sun, he suggested,[3] as long ago as the year 1833, that it would be a highly curious subject of experimental enquiry, to determine how far a mere reduplication of sheets of flame, one behind the other, would communicate to the heat of the resulting compound ray, the penetrating character, which distinguishes the solar calorific rays. Now two recent investigators claim a low temperature in the sun, and the argument of one of them, Mr. W. M. Williams, is founded upon a development of the idea thus advanced by Herschel in 1833, and a study more or less reliable, of superposed radiant surfaces, more especially of certain methods of heating iron plates, by radiant heat from gas flames, of low temperature, but great body. Many students of solar physics remark the close resemblance of the sun's surface phenomena to those presented by a fused flux or slag, and its surface crust; but the assumption that the sun actually consists of a fused mass, covered by a pasty or solidifying crust, has been opposed by four apparently inconsistent conditions, namely:—first, its supposed enormously high temperature; —second, its supposed gaseous, because dark, interior;—third, the supposed necessity that a more luminous crust should be at a higher temperature than the fused material of which it is formed;—and fourth, its low specific gravity. If the present tendency to lower the temperature of the sun ends in the general acceptance of figures even approximately as low as those of Dr.

3 Herschel, J. F. W. Outlines of Astronomy; New York, 1859, page 212. Note from edition of 1833.

Siemens,[4] Mr. Williams[5] and M. Violle,[6] the assumption that the known constituents of the sun must be wholly gaseous, will, in so far as temperature is concerned, be no longer necessary, and the idea that it is a sphere of fused material, such as originally constituted our melted earth, or such as is now ejected by terrestrial volcanoes, will be quite admissible; and it seems to me that the experiments I have herein apparently correlated will then account for its dark interior. For, assuming it to be a perfectly limpid fused globe, like many a blow-pipe bead at about that temperature, covered with a crust of less fusible or incompatible material, crystallizing out from the mass, as feldspar and hornblende perhaps crystallized out from granite, or a crust of the same material reduced to a pasty or opaque condition upon the surface, by the chill of its radiation into surrounding space, the great luminosity of the crust would be perfectly consistent with its temperature, whether the same as that of the sun or lower, and the predicated phenomena of its surface would almost precisely accord with those actually observed. Internal convective disturbances and general equilibrium currents of the crust, in large areas, by whatever cause produced, should give rise,—the first to the production of the willow-leaves, faculæ, and spots,—and the latter, to their actual translation over the sun's surface. Every little local depression of the pasty crust would cause a slight local exudation of the interior transparent lava, which would chill by radiation, become opaque and brightly luminous, and then gradually retrograde to a condition of incandescence determined by the general temperature of the surface, and where especially violent local disturbances, such as gaseous eruptions, might break away or part the crust, there the interior would seem, as it actually would be, non-luminous or dark.

The common assumption that the red protuberances or so-called hydrogen flames are of the nature of flames, and consist of hydrogen gas at a temperature enormously high, I am disposed to question, for I am unable so far to find the evidence of

4 Siemens, Dr. C. W. Solar Physics. Lecture at the Royal Institution, April 27, 1873. Nature, Vol. 28, p, 19.

5 Williams, W. Mattieu. Fuel of the Sun. Humboldt Library, No. 41, p. 215.

6 Compte Rendus, Vol. LXXVIII, pp. 186 and 1425,

a single physical experiment, to show that hydrogen can be caused to glow with a red light or yield its characteristic spectrum by heat alone, or that it is actually highly heated by the electric influence which causes it thus to glow when rarified in a Geissler tube. On the contrary, the temperature of the sun might be comparatively low, yet if still above the temperature of the dissociation of water (approximately 4,800 degrees C.)[7] be consistent with all the eruptive phenomena of the chromosphere and protuberances, the chromatic phenomena of which inconsistent with that temperature may it seems to me, as yet be attributed to purely electrical influences. If the maintenance of the opening in the crust which we call a spot, were consistent with a comparatively quiet condition of the surface upon which the crust floats, the penumbra might perhaps be an image of the the interior side of the crust seen through the sun's mass, or it might be the less luminous reflection of the side of the opening from the sun's actual surface. Were the mass of the sun metallic, the image would appear almost as bright as the reflected object, like the image of a ring of litharge, reflected from the surface it surrounds, or of a button of silver, melted in a scorifier or cupel ; but if the sun be a mass of a transparent silicate, the image would be far less brilliant than the side of the cavity in the crust. And in this connection it may be remarked, that in certain details many of the drawings of sun-spots which have been published appear to afford to a person prejudiced in its favor, striking illustrations of this hypothesis, and the famous representation of a sun-spot reproduced in almost all astronomical works, and which was drawn by Prof. Langley without reference to such an hypothesis, would seem to support it conclusively, for it shows a projection of the crust over an annular chasm and its apparent image in a mirror-like surface beneath.

If, whatever the size of the sun-spot, the penumbra be found to have approximately always the same width, that it is an image of the walls of the chasm would be strongly indicated, but it by no means follows that it must be such an image to accord with this hypothesis.

On the contrary, while reflection would still occur to a greater or less extent, the penumbra might actually be a thin film, of

7 Deville.

low incandescence, such as usually forms upon a slag when its surface is exposed by the removal of its crust, spreading to the sides of the spot and leaving in the centre a clear space; and nothing in the admission of such a film is perhaps irreconcilable with ordinary penumbral phenomena.

Undoubtedly this hypothesis should be carefully considered and submitted to the test of elaborate experimental examination, before it could claim acknowledgment as a theory; but although the low specific gravity of the sun still opposes its acceptance, unless perhaps it may be a mean of the specific gravities of the liquid sphere and its gaseous surrounding atmosphere, I concluded with some diffidence to advance it as naturally suggested by the experiments herein described.

Should it survive the scrutiny of critical consideration, it will afford us the satisfaction of at least partly solving an important problem, and furnish a striking illustration of the connection of *small* things with *great*, in the transition of reasoning from the phenomena of a blow-pipe bead to the phenomena of the sun.

IX.—*A Revision of the North American Species of the Genus Scleria.*

BY N. L. BRITTON.

Read May 25th, 1885.

The genus SCLERIA contains, according to Bentham and Hooker, about one hundred species, distributed throughout the warmer regions of the globe, in North America alone extending into the higher temperate zone—one species reaching even into Canada. The materials on which the present arrangement of our forms is based comprise the specimens in the Philadelphia Academy of Natural Sciences; in Dr. Gray's Herbarium; in the Torrey, Meisner, and Chapman Herbaria, of Columbia College; those of the Torrey Botanical Club; of the private herbaria of Judge Addison Brown, Mr. I. C. Martindale, and Mr. J. H. Redfield, and my own collection for the Geological Survey of New Jersey.

Scleria.—Berg. in K. Vetensk. Acad. Handl., Stockholm, xxvi (1765), 142, t. 4, 5. Flowers unisexual, the fertile solitary, in androgynous spikelets below the sterile, or in distinct spikelets; the sterile indefinite in number in androgynous or distinct spikelets. Glumes imbricated on all sides, the 1—3 lower and sometimes 1—3 above the fertile flowers empty. Bristles of the hypogynium none. Stamens 1, 2, or rarely 3. Style continuous with the ovary, terete, or somewhat swollen at the base; divisions of the stigma 3, filiform. Achenium globose or ovoid, often white, obtuse and erostrate, or mucronate by the short, persistent base of the style, the gynophore often supported by a simple or double cartilaginous dilated disk, which is rarely obsolete.—Herbs. Leaves either flaccid and grasslike, or long, broad, and plicate-nervose. Spikelets small, in terminal, or terminal and axillary, or glomerate-spicate fascicles. Bracts leaflike or setaceous. (Vide Bentham and Hooker, Gen. Plant., iii, pt. ii, 1070.)

(A) Inflorescence a single terminal cluster; achenium smooth and even, or longitudinally ribbed.

1. S. gracilis, Ell. Culms, very slender and sometimes filiform, ten to fourteen inches high, smooth; leaves filiform, smooth; bracts and scales glabrous; achenium ovate, obtusely triangular, obtuse, shining or dull, distinctly longitudinally ribbed, about 1½ lines long, with two pits on each side of the triangular base; perigynium none. Sketch, ii, 557; Kunth, Enum., ii, 359; Eaton and Wright, 419; Steud., Syn., 175; Dietrich, Syn. Plant., v, 254; Chapman, 532; Darby, 564; Wood, Class-book, 747; Bot. and Flor., 368; Bœckeler, Linnæa, xxxviii, 450; Grisebach, Cat. Flor. Cuben., 249.

Hypoporum gracile, Torr., Ann. N. Y. Lyc., iii, 381.

Habitat, South Carolina and Florida to Texas. Also in Cuba (Plantæ Cubenses Wrightianæ, No. 3420).

2. S. Baldwinii, Steud. Culms triangular, smooth, or somewhat rough above, one to three feet high; leaves linear, smooth, or slightly scabrous; achenium ovate, dull, smooth and even, about two lines long, obscurely triangular, apiculate, destitute of pits, the base triangular, pointed; perigynium none; bracts and scales glabrous. Syn., 175; Wood, Class-book, 747; Bot. and Flor., 368; Bœckeler, Linnæa, xxxviii, 450.

S. dioica, LeConte. in Herb. Acad. Nat. Sci. Phila.

Hypoporum Baldwinii, Torr., Ann. Lyc., iii, 382.

In a specimen collected in Western Florida by Dr. Chapman, and now in the Short Herbarium, Acad. Nat. Sci. Phila., there is an additional lateral cluster of spikelets.

Habitat, Florida to Texas.

Var. **costata,** n. var., Achenium longitudinally ribbed; otherwise as in the type.

S. Baldwinii, Chapman, 532.

Habitat, Georgia, Florida, Texas.

(B) Inflorescence in terminal, or in terminal and lateral, more or less peduncled clusters.

* *Achenium smooth.*

3. S. triglomerata, Michx. Culms triangular, 18 inches to 3 feet high, scabrous or nearly smooth; leaves broadly linear, smooth or slightly hairy, roughish on the margins; sheaths smooth; clusters near the summit of the culm, with or without additional smaller pedunculate ones from the lower axils, the upper one somewhat triglomerate; bracts naked or slightly ciliate, cuspidate ; achenium varying from depressed to ovate-globose, generally obtuse but pointed, obscurely triangular, shining ; perigynium narrow, very obtusely triangular, covered with a white rough crust.

Fl. N. A., ii, 168; Muhl., Gram., 269 ; Ell., Sketch, ii, 558; Pursh, Flor. Amer. Sept., i, 46 (?); Eaton and Wright, 418; Beck, 430; Darlington, Flor. Cestr., 2d Ed., 26; 3d Ed., 343; Torrey, Compend., 349; Ann. Lyc., iii, 380; Flor. N. Y., ii, 368; Steud., Syn., 173; Eaton, 454; Dewey, Plants Mass., 260; Chapman, 531; Darby, 564; Gray, Manual, 570; Wood, Class-book, 746; Bot. and Flor., 367; Bœckeler, Linnæa, xxxviii, 464.

S nitida, Willd., Herb., *fide* Kunth, Enum, ii, 350; Darby, 564 ; Steud., Syn., 174; Dietrich, Syn. Plant., v, 252.

S. flaccida, Steud,, Syn., 174.

Cladium triglomeratum, Nees, Linnæa, ix, 301 ; Kunth, Enum, ii, 304.

Trachylomia triglomerata, Nees, Mart., Flor. Bras., ii, Pt. i, 174.

Pursh describes the nut as rugose, but he must have confounded this with some other species.

Habitat, Massachusetts and Vermont to Wisconsin, and southward to Florida and Texas.

Var. **gracilis**, n. var. Culms slender, 15 inches to two feet long ; fascicles few-flowered, small, the lower of but two or three flowers on very long, filiform peduncles ; achenium not more than one-half the size of that of the type, ovate, acutish.

Habitat, Leeds Point, N. J., Dr. Gray's Herbarium ;—near Haddonfield, N. J., A. H. Smith ;—Quaker Bridge, N. J., W. H. Leggett.

4. S. oligantha, Ell. Culms about two feet high, slender, triangular, the angles somewhat winged ; leaves linear, about two lines wide, smooth except their scabrous apices ; lateral fascicles one or two, mostly on long exserted peduncles; bracts somewhat ciliate, scales ovate, cuspidate; achenium ovate, obtuse but generally pointed ; perigynium a narrow obtusely triangular border, supporting eight or nine small tubercles. Sketch, ii, 557 ; Michx., Fl. N. A., ii, 167 (?) ; Eaton and Wright, 419 ; Torrey, Ann. Lyc., iii, 377; Steud., Syn., 173; Chapman, 531; Bœckeler, Linnæa, xxxviii, 462.

S. leptoculmi Wood, Class-book, 746 ; Bot. and Flor., 367.

Scleria, No. 4, Muhl., Gram., 268.

Habitat, Virginia to Florida, and through the Gulf States to Texas.

Very distinct from *S. pauciflora,* Muhl., to which it has been referred by Willdenow and Pursh.

5. S. lithosperma, Willd., Sp. Pl., iv, 316; Var. **filiformis**. Culms slender, smooth, one to two feet long; leaves narrowly linear, somewhat scabrous on the margins and keel; sheaths ciliate at the throat; clusters 2–3, distant, erect, each interruptedly spicate; the upper with setaceous bracts, the lowest remote and leafy-bracted; scales lanceolate, acuminate, with rough points; achenium smooth and glossy, oblong or obovate, destitute of pores; base small, triangular; perigynium none. Whole plant somewhat glaucous.

S. lithosperma, Willd., (emend.) Var. 2, Bœckeler, Linnæa, xxxviii, 452.

S. gracilis, Richard, Act. Soc. Hist. Nat. Paris, i, 113, (Willd. *fide*)

S purpurea. Poiret, Encycl., vii, 4; Sprengel, Syst. Veg., iii, 832.

S. filiformis, Swartz, Fl. Ind. Occ., i, 91; Sprengel, Syst. Veg., iii, 832; Steud., Syn., 172; Kunth, Enum., ii, 348; Willd., Sp. Pl., iv, 316; Chapman, 532; Grisebach, Fl. Br. W. I., 579; Dietrich, Syn. Plant., v, 251.

Hypoporum purpurascens, Nees. Linnæa, ix, 303.

Habitat, Southern Florida. Also in Cuba and throughout the West Indies.

The type is native to Australia, the East Indies and Southern Asia; our plant differs from it mainly in its more slender habit.

* * *Achenium reticulated or irregularly rugose.*

6. S. reticularis, Michx. Culms slender, erect, triangular, scabrous, particularly below, or nearly smooth, one to two and a half feet high; leaves linear, one to one and a half lines wide, smooth; lateral fascicles of spikelets one to three, remote, nearly erect, on short, often included peduncles, loosely flowered; bracts and scales glabrous, the latter mucronate; achenium globose, distinctly reticulated, its reticulations quadrangular-oblong, pitted; perigynium conspicuous, 3-lobed, its lobes acute or somewhat obtuse, appressed to the base of the achenium.

Fl. N. A., ii, 167 ; Sprengel, Syst. Veg., iii, 831 ; Willd., Sp. Pl., iv, 314 ; Eaton and Wright, 419 ; Torrey, Ann. Lyc., iii, 375 ; Flor. N. Y., ii, 367 ; Gray, Manual, 570 ; Chapman, 531 ; Wood, Class-book, 747 ; Bot. and Flor., 368 ; Bœckeler, Linnæa, xxxviii, 467.

S dictyocarpa, Grisebach, Cat. Plant. Cuben., 249.

Habitat, Eastern Massachusetts and Rhode Island to Florida. Also in Cuba (Plantæ Cubenses Wrightianæ, No. 3416 a).

Var. **pubescens,** n. var. Edges of the reticulations more or less hairy, especially towards the apex of the achenium ; lateral fascicles generally on longer peduncles.

S. trichopoda, C. Wright, Plantæ Cubenses. No. 3803. Name not in Grisebach's Cat. Plant. Cuben.

Habitat, New Jersey Pine Barrens to Florida. Also in Cuba. (C. Wright No. 3800.) Often distributed as *S. laxa*, Torr., (*S. Torreyana*, Walpers), from forms of which species it can generally be distinguished by the absence of transverse or spiral ridges on the achenium.

Var. **obscura**, n. var. Achenium bony, its surface marked with very obscure reticulations, nearly even at the summit.

Habitat, Salem, North Carolina, Schweinitz ; Rhode Island, Thurber and Calder. All the specimens of this well-marked form which have come under my notice are in the herbarium of the Philadelphia Academy of Natural Sciences.

Var. **pumila**, n. var. Culms only 4 to 6 inches high, smooth ; leaves linear, short, smooth ; fascicles of but a single fertile and two or three sterile flowers, sessile or very short-peduncled ; achenium very nearly as in the type.

Habitat, Orizaba, Mexico, Botter, No. 774.

This species, as Dr. Torrey has already pointed out,* is closely allied to *S. tessellata*, Willd., of the East Indies, tropical Asia and Australia, differing mainly in its smaller size, more slender habit, and its fewer, smaller, nearly sessile lateral clusters. The achenium is practically the same in each.

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* Ann. Lyc., iii, 376.

7. S. Torreyana, Walpers. Culms weak, diffuse, slightly scabrous or smooth ; leaves linear, two to four lines wide, smooth ; lateral fascicles on more or less elongated filiform peduncles, loosely flowered ; scales and bracts smooth ; achenium globose, somewhat pointed, irregularly rugose with ridges arranged in a somewhat spiral manner, or by the anastomosing of these with shorter longitudinal ridges, somewhat or even distinctly reticulated, its ridges more or less hairy, or sometimes smooth ; perigynium three-lobed, the lobes acutish and appressed. Ann., iii, 696 ; Bœckeler, Linnæa, xxxviii, 468.

S. reticularis, Muhl., Gram., 266 ; Pursh, Flor. Amer. Sept., i, 45 ; Ell., Sketch, ii, 560 ; Kunth, Enum., ii, 348 ; Dietrich, Syn. Plant., v, 252.

S. laxa, Torrey, Ann. Lyc., iii, 376 ; Flor. N. Y., ii, 368 ; Gray, Manual, 570 ; Chapman, 531 ; Wood, Class-book, 747 ; Bot. and Flor., 368. (Not of R. Brown).

S. Muhlenbergii, Steud., Syn., 173.

S. hemitaphra, Steud., Syn., 169.

S. debilis, Wright, Plantæ Cubenses, No. 3416 pp., a form with smooth achenia.

S. bracteata, Cav.; var. *angusta*, Griseb., Flor. Br. W. I., 579.

Habitat, Pine-Barrens of New Jersey to Florida, and through the Gulf States to Mexico. Also in Cuba (Plantæ Cubenses Wrightianæ, Nos. 3802, 3416, 720).

* * * *Achenium papillose or warty.*

8. S. ciliata. Michx. Culms one to two feet high, slender, smooth, or more usually scabrous or hairy above ; leaves narrowly linear, smooth or pubescent ; sheaths hairy ; inflorescence generally a single terminal cluster; sterile spikes large ; bracts conspicuously ciliate ; achenia globose or globose-ovoid, pointed, roughened with scattered unequal warty projections or ridges, those at the base larger and deflexed ; perigynium a narrow obtusely triangular border, supporting three hemispherical entire tubercles. Flor. N. A., ii, 167 ; Willd., Sp. Pl., iv, 318 ; Pursh, Fl. Amer. Sept., i, 46 ; Ell., Sketch, ii, 559 ; Torrey, Ann. Lyc., iii, 378 ; Dietrich, Syn. Plant., v, 252 ; Kunth, Enum., ii, 350 ; Eaton and Wright, 419 ; Steud., Syn., 173 ; Wood, Class-book, 746 ; Bot. and Flor., 367 ; Chapman, 531 ; Darby, 564 ; Bœckeler, Linnæa, xxxviii, 463.

Habitat, South Carolina to Florida.

S. ciliata is in its fruit-characters very similar to *S. pauciflora*, especially resembling the var. *Elliottii* of the latter species. It may generally be distinguished by its solely terminal inflorescence and by the three distinct and entire tubercles above the perigynium. In all the forms of *S. pauciflora* there are either six, or three two-lobed, tubercles.

9. S. pauciflora, Muhl. Culm slender, erect, 9—24 inches high, smoothish or hairy ; leaves narrowly linear, smoothish ; sheaths more or less pubescent ; fascicles few-flowered, the lateral sessile or pedunculate or sometimes absent ; bracts more or less ciliate, glumes acute or acuminate, naked ; achenium globose-ovate, the papillæ toward the base elongated and depressed ; perigynium a narrow obtusely-triangular border, supporting six small globose tubercles somewhat approximated in pairs.

In Willd., Sp. Pl., iv, 318 ; Gram., 267 ; Pursh, Flor. Amer. Sept., i, 46 ; Ell., Sketch, ii, 559 ; Darlingt., Flor. Cestr., 2nd Ed., 26 ; 3d Ed., 344 ; Spreng., Syst. Veg., iii, 832 ; Eaton and Wright, 419 ; Torrey, Ann. Lyc., iii, 377 ; Compend., 349 ; Flor. N. Y., ii, 369 ; Kunth., Enum., ii, 349 ; Dietrich, Syn. Plant., v, 252 ; Beck, 430 ; Eaton, 454 ; Gray, Manual, 571 ; Chapman, 531 ; Steud., Syn., 173 ; Wood, Class-book, 746 ; Bot. and Flor , 367 ; Bœckeler, Linnæa, xxxviii, 461.

S. Oakesiana, Robbins in Gray Herbarium.

Habitat, New Hampshire to Ohio, and southward to Florida and Texas. Also in Cuba (Plantæ Cubenses Wrightianæ, No. 3799).

Var. **Caroliniana,** Wood. Stems very slender, pubescent, as also the sheaths and leaves ; achenium wrinkled or papillose.

Bot. and Flor., 368.

S. Caroliniana, Willd., Sp. Pl., iv, 318 ; Torrey, Ann. Lyc., iii, 379 ; Steud., Syn., 179 ; Kunth., Enum., ii, 359 ; Darby, 564 ; Dietrich, Syn. Plant., v, 254.

Spermodon, sp., Endlicher, Gen. Pl., 114.

S. hirtella, Michx., Fl. N. A., ii, 168(?) ; Eaton and Wright, 419 ; Ell., Sketch, ii, 560.

S. pauciflora, var. *hirtella,* Chapm. in Herb.

Habitat, South Carolina and Florida.

Var. **Elliottii,** Wood. Culms stout, erect, densely rough-pubescent on the angles, leaves broader than in the type, hairy ; sheaths pubescent ; lobes of the perigynium three, each two-lobed.

Bot. and Flor., 368.

S. Elliottii, Chapman, 531.

S. hirtella, Michx, Fl. N. A., ii, 168(?).

S. hirtella, Michx., var. *strigosa*, Ell., Sketch, ii, 560; Eaton and Wright, 419.

Habitat, North Carolina to Florida, and through the Gulf States to Texas and the Indian Territory. Also in Cuba (Plantæ Wrightianæ, No. 3798).

Var. **glabra**. Chapman. Smooth throughout, or the leaves and bracts somewhat scabrous at the summit; processes of the perigynium three, each two-lobed; achenium wrinkled or papillose.
Flor. South. States, 532; Wood, Bot. and Flor., 368.

Var. β, Torrey, Ann. Lyc., iii, 378.

Habitat, North Carolina to Florida.

Var. **elongata**, n. var. Smooth throughout; stems very slender, two to two and a half feet long, diffuse: achenium as in the last variety.

Habitat, Georgia, Florida.

(C.) Inflorescence interruptedly glomerate-spicate.

* *Achenium smooth; pistillate scales bristly.*

10. S. hirtella, Swartz. Culms 6—19 inches high, slender, smooth or nearly so; leaves linear and, with their sheaths, hairy; clusters of flowers 4—8, sessile, erect or nodding; scales of the fertile flowers oval or lanceolate, cuspidate; those of the sterile flowers lanceolate or linear, pointless, glabrous; achenium globose, half a line broad, pointed, its base somewhat attenuated, triangular, each side furnished with from 5—7 minute pores; perigynium none.
Fl. Ind. Occ., i, 93; Sprengel, Syst. Veg., iii, 832; Kunth., Enum., ii, 353; Steud., Syn., 175; H. B. K., Nov. Gen. et Sp. Pl., i, 132; Grisebach, Fl. Br. W. I., 579; Dietrich, Syn. Plant., v, 253; Bœckeler, Linnæa, xxxviii, 439.

S. humile, Nees, Linnæa, ix, 303.

S. distans, Poiret, Encycl., vii, 4; Kunth., Enum., ii, 353; Steud., Syn., 176; Dietrich, Syn. Plant., v, 253.

S. nutans, Kunth, Enum., ii, 351; Steud., Syn., 175; Dietrich, Syn. Plant., v, 252.

S. mollis, Kunth, Enum., ii, 352; Steud., Syn., 175; Dietrich, Syn. Plant., v, 252.

S. cenchroides, Kunth, Enum., ii, 352 ; Steud., Syn., 175 ; Dietrich, Syn. Plant., v, 252.

S. interrupta, Michx., Fl. N. A., ii, 168 (*fide* Torrey, Ann. Lyc., iii, 383) ; Wood, Class-book, 747 ; Bot. and Flor., 368.

S. Michauxii, Chapman, 532.

Hypoporum hirtellum, Nees, Linnæa, ix, 303 ; Mart., Flor. Bras., ii, Part i, 170.

H. humile, Nees, Linnæa, ix, 303.

H. nutans, Nees, in Mart., Flor. Bras., ii, Pt. i, 170.

H. interruptum, Nees, Linnæa, ix, 303 ; Torrey, Ann. Lyc., iii, 382.

Habitat, Florida to Louisiana. Also in Mexico, Central America, Columbia, Peru, Chili, Venezuela, Guiana, Brazil, the West Indies, and Middle and Southern Africa.*

Var. **pauciciliata**, n. var. Scales sparingly ciliate-bristly or nearly naked.

Cuba, Plantæ Cubenses Wrightianæ, No. 3418, mixed with *S. tenella*, Kunth, in Dr. Gray's Herbarium.

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* Pursh records *S. hirtella*, Willd., in Flor. Amer. Sept., i, 46, as growing "in dry woods on slate rocks : Virginia, Carolina. The smallest species." Dr. Torrey notes on the margin "Pursh's plant in Herb. Lamb. is *Isolepis stenophylla*."

Here may be noted :—

S. interrupta, Richard. Closely resembles *S. hirtella*, Swartz, differing in the transversely tuberculate-rugose achenium.

Act. Soc. Hist. Nat. Paris, i, 113 ; Flor. Abyss., 511 (*fide* Bœckeler) ; Kunth, Enum., ii, 352 ; Willd., Sp. Pl., iv, 318 ; Steud., Syn., 175 ; Darby, 564 ; Pursh, Flor. Amer. Sept., i, 45 ; Dietrich, Syn. Plant., v, 252.

S. Kunthiana, Steud., Syn., 176.

S. verticillata, Kunth, Enum., ii, 353 ; Dietrich, Syn. Plant., v, 253.

S. hirtella, Swartz, var. γ, Bœckeler, Linnæa, xxxviii, 441.

I have seen no specimens of this plant from North America, though it has been recorded by several authors. It occurs in Cuba (Plantæ Cubenses Wrightianæ without a number, and mixed with *S. verticillata*, Muhl.), and was originally described from specimens collected in French Guiana. Bœckeler (Linnæa, xxxviii, 441), reduces it to a variety of *S. hirtella*, Swartz, but I regard it as a distinct species. The achenium is very similar to that of *S. verticillata*.

** *Achenium with short, transverse ridges, or by additional longitudinal ridges, somewhat reticulated ; scales naked.*

11. S. verticillata, Muhl. Culms slender, simple, 4—24 inches high, smooth ; leaves narrowly linear and, with their sheaths, smooth, or somewhat hairy ; clusters of flowers 3—9, sessile, generally erect ; bracts setaceous ; scales smooth ; achenium globose, half a line broad, somewhat triangular at the base, its sides destitute of pores ; perigynium none.

In Willd., Sp. Pl., iv, 317 ; Gram., 266 ; Ell., Sketch, ii, 561 ; Pursh, Flor. Amer. Sept., i, 45 ; Spreng., Syst. Veg., iii, 832 ; Eaton and Wright, 419 ; Torrey, Compend., 349 ; Flor. N. Y., ii, 369 ; Steud., Syn., 176 ; Eaton. 454 ; Gray, Manual, 571 ; Chapman, 532 ; Wood, Class-book, 747 ; Bot. and Flor., 368 ; Bœckeler. Linnæa, xxxviii, 445.

Hypoporum verticillatum, Nees, Linnæa, ix, 303 ; Torrey, Ann. Lyc., iii, 384.

Habitat, Long Island, Eastern Massachusetts, Southern Canada, Michigan and southward. Also in Texas, Mexico, and Cuba. I have found the achenium of this species reticulated only in southern specimens ; the northern forms produce achenia which are marked with short, distinct, transverse ridges ; in a plant from Biscayne Bay, Florida, (E. Palmer, 1874) nuts with each style of ornamentation occur.

It is allied to the East Indian and African *S. pergracilis*, Kunth, Enum., ii, 354, as has been remarked by Dr. Torrey (Ann. Lyc., iii, 384), which may however be distinguished by its rather tuberculate achenium, and oblong or ovate bracts.*

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* Here may be noted

S. tenella, Kunth, Enum., ii, 352. Culms slender ; inflorescence branched or simple ; achenium finely reticulated, one half the size of that of *S. verticillata.*

Bœckeler (Linnæa, xxxviii, 446), unites this species with the last ; but I believe them to be distinct. *S. tenella* grows in Cuba, Mexico, Columbia, Guiana and Brazil. It is figured in Mart., Flor. Bras., i, pt. ii, 171, t. 9, fig. 2. *S. verticillata* is said by Bœckeler (ibid.), to occur in Sierra Leone ; but as he regards the species as inseparable, I cannot say which is meant. I have seen no African specimens of either.

X.—*On Hanksite, a new Anhydrous Sulphato-Carbonate, from San Bernardino County, California.*

BY WM. EARL HIDDEN.

Read May 25th, 1885.

In the very complete and attractive exhibit of California minerals brought to the World's Industrial and Cotton Centennial Exposition at New Orleans, by Prof. Henry G. Hanks, State Mineralogist of California, were several species of unusual interest.

Among these, was the new borate, Colemanite, with its large and lustrous crystals so much resembling the finest of the Bergen Hill datolites; the new vanadium mica, Roscoelite, mixed as it is mechanically with much native gold between its folia: borax crystals, clear and bright, of unusual size; stibnite in superb crystals almost equalling the late discoveries in this species in Japan, and many others equally noteworthy, and to which I may refer in a separate paper later.

Of particular interest to the writer was a small lot of *apparently hexagonal crystals* to which had been given the name of "Thenardite." Now as Thenardite is asserted in the text books to be orthorhombic, I was prompted to measure the angles of these crystals. Their seeming non-conformity in shape pointed to the possibility of their being new—in angle, or type of form, especially. The results confirmed my first suspicions of their true hexagonal character, though my measurements were only approximate, being made with a hand goniometer.

Since the hexagonal character of the mineral, which seemed so evident, might possibly be due to complex twinning of orthorhombic individuals, it seemed advisable to have this question decided on the basis of an optical examination; and for this purpose three of the best crystals were kindly given by Prof. Hanks, and sent by me to Dr. Edward S. Dana for that exact crystallographic definition needed in this case, and which he always so ably and generously gives to science. The crystals sent being quite clear, Dr. Dana was, in a few days, enabled to report them "as uniaxial (double refraction negative) and that normally," and thus their positive difference from Thenardite was proven beyond question. They were true *hexagonal* crystals. Believing now the mineral to be either a dimorphous form of sodium sulphate, or possibly an entirely new species, an analysis seemed necessary. Accordingly I placed sufficient material in the hands of Mr. James B. Mackintosh, E. M., for that purpose, and he has very kindly done the work. His results showed the mineral to contain the following substances :

SO_3 - - -	45.89
CO_2 - - -	5.42
Cl. - - -	2.36
*Na_2O - - -	46.34

Corresponding to

$Na_2 SO_4$ - -	81.45
$Na_2 CO_3$ - - -	13.06
Na Cl - - -	3.89
$Na_2 O$ (excess) -	1.08
	99.48

These results give the following molecular ratios for

$Na_2 SO_4$ - -	57.3	or	3.95
$Na_2 CO_3$ - - -	14·5		1.00
Na Cl - - -	6.65		.46
$Na_2 O$ - - -	1.74		.12

Or closely in the ratio of $4 : 1 : \frac{1}{2} : \frac{1}{8}$. This all points to the formula,

$$4\,(Na_2\,SO_4) + 1\,(Na_2\,CO_3) + \tfrac{1}{2}\,(Na\,Cl)$$

as representing the composition of the crystals under examination. Or, neglecting the sodium chloride as non-essential, the formula could be given thus:—

$$4\,Na_2\,SO_4 + Na_2\,CO_3$$

which is probably the true one.

* All bases calculated as soda. Lime and magnesia were not present.

The observed excess of soda is either due to errors of analysis, as only a small quantity was used, or it may have been combined with boracic acid, as borax is very abundant at the locality.

The interesting anomaly of a sulphate and carbonate being in chemical combination reminds us of the rare sulphato-carbonate of lead, Leadhillite, to which this alone bears relation as a natural species.

The angles I obtained were as follows :—

O on I = 90°.	O on 1 = 130° 30′
I on I = 120°.	O on 2 = 113° 30′

Accordingly the value of the vertical axis is 1.17085. Cleavage parallel to O nearly perfect, but difficult to obtain.

Crystals striated horizontally. They are commonly terminated at both ends of the prism and are very symmetrical in shape. They average, as thus far seen, about one centimeter in length and thickness, with O and I as predominating planes (see fig. 1).

Fig. 1.

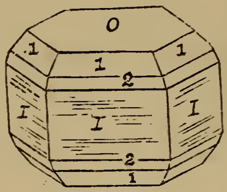
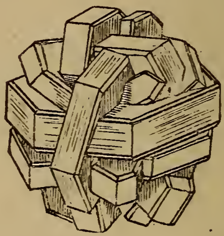


Fig. 2.



Sometimes the crystals are confusedly grouped (see fig. 2), as from a common centre, much like the Aragonite from a noted European locality. For some late years mineralogists have received from several localities in the far West, groups of crystals that were hexagonal (tabular) in appearance, very impure in composition, and to which the name of Aragonite has been attached. For the most part they are simply calcium carbonate mixed with sand and mud, and are without cleavage. It is very probable that they are pseudomorphs after the sodium sulphato-carbonate here described. In particular I refer to crystals which I have seen credited to Colorado and to Nevada.

The crystals here analysed were found with salt, Thenardite, tincal, etc., at the works of the San Bernardino Borax Co., in San Bernardino County, California.

The density of this new California mineral is 2.562. Its hardness, 3.–3.5. It is readily soluble in water. Effervesces with acids. It affords, when dissolved in water, an abundant precipitate of barium sulphate when barium chloride is added to the solution. On addition of silver nitrate, to a fresh solution, chloride of silver is precipitated, showing that chlorine is also present. Gentle ignition developes no appreciable loss in the weight of the mineral.

The crystals are transparent to semi-opaque, with a white waxy color inclining to yellow. Surfaces never highly polished or very smooth.

The definite formula deduced from Mr. Mackintosh's analysis, taken together with the form, warrants me in announcing these crystals as a new mineral species. I therefore propose for it the name of Hanksite, after Prof. Henry G. Hanks, of California, than whom no man has done more to give to the world a correct knowledge of the minerals of the great States of our Pacific coast.

NEWARK, N. J., May 23, 1885.

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NEWARK, N. J., May 23, 1885.

XI.—*Notes on the Geology and Botany of the Country bordering the Northern Pacific Railroad.*

BY J. S. NEWBERRY.

Read February 4th, 1884.

Having been several times over the line of the Northern Pacific R. R., and through the country bordering the lower Columbia and Puget's Sound, and having found some things that were of interest to me, I venture to offer a few notes upon them to the members of the Academy.

Going west from Duluth to Brainerd, the line of the road for the most part lies in what is evidently the old deserted bed of a westward extension of Lake Superior. The ground is still low and swampy, and much of the surface is formed of what is unmistakably lake sand.

From Chicago through Wisconsin and Minnesota, the road passes over an almost unbroken sheet of drift, which though of great interest, has been so fully illustrated in the able reports of Messrs. Chamberlin, Winchell and Upham, that nothing further need be said here in regard to it. At various points the true till is seen, with its striated pebbles; and one such exposure is within reach of every traveler, at Audubon. Beyond this, the boulders are scattered over the surface, and pebbles in the ditches continue as evidence of the transport of material from the eastern highlands. About Bismarck the boulders, though fewer, are still not rare, and are gathered in groups, as elsewhere along the margin of the drift area, constituting a kind of fringe, and suggesting their transport by ice floats. The last of these boulders is seen at Sims, about 20 miles from Bismarck. From this point to the crossing of the Little Missouri, one could hardly find a stone to throw at a bird, or a shrub big enough to make a tooth-pick. This region is an extension northward of that broader prairie area which I have crossed in many places further south. Here, between the eastern drift and that from the Rocky Mountains, the soil is formed entirely by the decomposition of the underlying rocks; and wherever these are shales and calcareous sandstones, as they are throughout most of the Cretaceous formation, there are no outcropping ledges of rock, the country is smooth, and stone of all kinds is scarce.

This belt, which runs from the Mexican to the Canadian line, is prairie because of the dryness of the climate, and not on account of the geological substructure; for, between the "Cross-timbers" and the Raton Mountains, with a great variety of geology and topography, there are no trees except along the water-courses; which, fed by the melting of the snow on the Rocky Mountains, are perennial, and supply constantly the amount of moisture that is a necessity for tree growth. The peculiar fineness of the soil of the northern portion of this belt has been supposed to have something to do with the prevalence of grass and the absence of trees; since in Illinois and Wisconsin, along the border line between the forest area and the prairie, the levels where the soil is fine are grass-covered, while the swells and ridges, rocky or gravelly, carry trees; but as I have shown elsewhere, these local peculiarities of the soil, favoring, the first grass and the second trees, have simply caused the interlocking of prairie and forest along the debatable line.

Further west, with every kind of soil, geological structure and topography, there are no trees, but everywhere grass; while east of the Mississippi and beyond the ba tle-ground between the two forms of vegetation, all kinds of topography, soil and geological substructure are covered with forest. No one who has traversed the continent, as I have done, along several parallels of latitude, and has studied the relations of vegetation to soil and geological structure, will fail to find conclusive evidence that the influence which has determined the kind and quantity of vegetation in the varied topographic and climatic districts of the West, is the rainfall.

The valley of the Little Missouri is deeply cut in a table-land composed of the Laramie coal-measures, of which 200 or 300 feet are exposed in the cliffs, with several seams of coal. Thousands of silicified tree-trunks lie scattered over the surface, and innumerable stumps are standing apparently where they grew; but no foreign material is anywhere visible.

A few miles below the railroad crossing, the valley expands and opens into the famous *mauvaises terres*, or "bad lands of the Missouri." The course of that stream is here nearly east and west; and the valleys of the tributaries running north and south, coalesce, and form in the old lake-bed a picturesque but dangerous labyrinth.

As soon as one enters the valley of the Yellowstone, he finds himself surrounded by transported material. Gravel and boulders of crystalline, sedimentary and volcanic rocks form the bed and bars of the river, increasing in coarseness and quantity all the way to Livingston; but in all this material I was unable to find anything that was to me even presumably of eastern origin. Dr. C. A. White, (Am. Journal of Sci., vol. XXV, 1883, p. 206,) reports finding what he considers eastern glacial drift along the valley of the Missouri and that of the Yellowstone; but my search for such material was vain. As will be seen further on, I found in the valley of the Missouri about the Falls, great quantities of drift with boulders of fossiliferous limestone, quartzite, gneiss and granite, all remarkably like the Eastern drift, but which I subsequently traced to their places of origin in the Belt Mountains.

The surface geology of the Yellowstone Park has been described in considerable detail by Mr. W. H. Holmes and Mr. A. C. Peale; but I was surprised to find the traces of glacial action so wide-spread and unmistakable. It is probably not too much to say that every valley of the Park was once filled with ice; for moraines, boulders, glacial lakes, and more rarely glacial striæ, give testimony that cannot be disputed. Ice-borne blocks are seen on the sides of the Yellowstone valley, below the mouth of Gardner's River; and about Mammoth Hot Springs, every depression once held a glacier. Swan Lake is of glacial origin, and is bounded on the south by a moraine, while lateral moraines and striated rock-surfaces mark the old ice-level high up on the sides of the valley. Near Marshall's, the road leads over a succession of great moraines of clay and boulders, which continue to and around the Fire Hole basin, and prove that this also was once largely filled with ice. From all that I could learn, the evidences of glacial action, found here in the lowest portion of the Park, may be traced through all parts of it.

Between Livingston and Bozeman, the railroad passes over a spur of the Rocky Mountains composed chiefly of Palæozoic limestones, part of which are Carboniferous. Above these are red beds which probably represent the Jurassic and Triassic, and still higher Laramie rocks with coal, apparently the same section exposed in Cinnabar Mountain, in the valley of the Yellowstone just north of the Park. The strata are very much disturbed, the coal much crushed and twisted, so that it works small, but it is extensively mined for use on and along the railroad, and is esteemed a good fuel. Fossil plants associated with the coal, prove it to be of the same age with that exposed in the cliffs at the crossing of the Little Missouri. One feature of the Bozeman coal it has in common with some of that from much disturbed beds in Washington Territory and Colorado. It contains a large quantity of yellow, translucent amber-like resin, in seams and patches. As this occurs in the joints of the coal, it is evidently a secondary product resulting from its partial distillation.

Drift of the Upper Missouri.

The Missouri River, formed by the union of the Madison, the Gallatin and the Jefferson, at Gallatin City, traverses with a north-westerly and then northerly course, the valley between the Rocky and Belt Mountains, and finds its way out to the plains by a long circuit around the northern bases of the Belt and Crazy Mountains, which belong to the Rocky Mountain system, and constitute their eastern outliers. Cutting through barriers formed by low interlocking spurs, at the "Gate of the Mountains," the river enters an undulating prairie country which extends from the north side of the Belt Mountains to and beyond the Canadian line. All this region is occupied by a sheet of drift that in thickness and extent rivals that of the plains surrounding the Canadian highlands; but as far my observation extended I found this to be of local origin.

At the Great Falls of the Missouri, the underlying rock is fully exposed, but the drift sheet comes up to the edge of the gorge and forms the low hills which stretch away to the east and north like the long swells of the ocean. In the valleys of the streams which come down to the Missouri from the Belt Mountains, the rock substructure is visible; but the intervening plateaus are covered with a sheet of drift clay and boulders, that varies greatly in thickness, as it is spread over a rock-surface that was once deeply and irregularly eroded. For example, near the Upper Falls of the Missouri, where the banks of the river are perhaps a hundred feet high, of solid rock, a tributary coming in from the south cuts across an old valley filled with drift which extends almost to the present river channel. At its mouth, this tributary has high rocky banks; but a few hundred yards above, they are altogether composed of drift. This drift is a true till, thickly set with boulders, some of which are two feet or more in diameter. They are usually rounded, sometimes subangular, and are composed of gray or red granite, quartzite, palæozoic limestone, and a variety of eruptive rocks. The resemblance of this drift to that from the Canadian highlands, is so great that I was only convinced of its local origin when I found all of its constituents in place in the Belt and Rocky Mountains. The granites were to my eye indistinguishable from those of the eastern Laurentian series; they are of Archæan age, as I subsequently learned; and nothing but careful microscopic examination will show them to be distinguishable, if they are so. These facts lead me to suspect that even the very careful and experienced observers who have reported the finding of eastern Laurentian boulders on the flanks of the Rocky Mountains, 4,000 feet above the sea, may have been misled by this striking resemblance.

On the undulating surface of the table-lands between the tributaries of the Missouri, large boulders are occasionally seen, as in the States bordering the Great Lakes; and one of these, somewhat angular in form, has served so long as a rubbing-post for the buffaloes which recently abounded in that region, that its sides are all polished and a deep furrow is worn around it.

Immediately south of the Falls of the Missouri, an extensive coal-basin of Cretaceous (?) age is opened by the valleys of the streams which come down from the Belt and Highwood Mountains. Two coal seams are exposed, one thin, the other from 12 to 18 feet in thickness, the latter a compound seam, some of the benches of which are bright, pure coking coal.

The Falls of the Missouri, caused by beds of sandstones belonging to this coal formation, consist of a series of cascades having an aggregate height of over 200 feet; the lower fall is 98 feet, the next 25, the next 40, the next 20, etc. They occupy the whole breadth of the river, which is here about 1500 feet; and as the volume of water is large, they are exceedingly beautiful and also furnish a water-power rivalling in magnitude that of Niagara, and far more available.

Geology of the Belt Mountains.

The streams which flow into the Missouri from the Crazy and Belt Mountains, form valleys which are remarkably picturesque and of great geological interest. The coal-basin to which I have referred is underlain by palæozoic limestones more than two thousand feet thick. These rise toward the south, where they rest upon the Cambrian and Archæan nucleus of the mountains. Deeply cut by the draining streams, they form the walls of a series of narrow valleys or cañons, which, though less impressive in magnitude, are more beautiful than those of the Colorado. The limestones are sometimes blue, more generally cream-colored, and lie in massive beds of 100 to 200 feet in thickness; these form a series of steps in the precipitous walls of the valleys, from which project spires, castles, fortifications, and other colossal imitations of human architecture. The light cream tint of the prevailing limestone contrasts charmingly with the dark green of the fir-trees that crown the summits and cluster in picturesque groups wherever they can find a foothold on the declivity. Add to these elements a variety of minor plants, which with varied colors decorate the cliffs, and the whole forms a combination which in beauty surpasses anything that I have elsewhere seen in somewhat extended wanderings through the far West.

Cutting through the limestones and in places the coal-bearing rocks, are eruptive dykes of three distinct kinds, which Mr. J. P. Iddings has been kind enough to examine for me microscopically. He reports them to be, first, a typical augite-andesyte, which forms the Bird Tail Divide and the upper portion of "Square Butte," a conspicuous landmark on the west side of the Missouri; second, a true trachyte, with large crystals of feldspar, much like that of the Drachenfels, at the head of Belt Creek; and third, a rhyolite, on the summit of Little Belt Mountain.

At Neihart, the centre of the Archæan nucleus of the Little Belt Mountains is reached. The prevailing granite is reddish and somewhat banded with brown and green, and though very massive is indistinctly bedded and apparently metamorphic. It is cut by enormous dykes of a very coarse and mottled granite, consisting of obscurely rounded masses of feldspar separated by hornblende and black mica. These granite rocks are traversed by a great number of fissure-veins, generally with vein-stones of quartz, heavy spar, and oxide of manganese, and carrying sulphides of silver and lead; the ores are rich but the veins small.

On the south side of the valley at Neihart the cliffs of granite, 1200 feet in height, are covered with a sheet of Potsdam sandstone several hundred feet in thickness, the contact being visible for miles. The sandstone is red, generally soft, but sometimes a coarse and hard conglomerate. It here contains no fossils, but is full of annelid borings (*Scolithus*), and has the aspect—as it has the geological relations—of the Potsdam in the Black Hills and in the Adirondacks. On the summit of the mountain, some of the upper beds of sandstone are filled with, and largely composed of, primordial trilobites.

The evidences of former glacial action in the Belt Mountains are abundant but are not of a striking character. They consist of beds of boulder clay, and in some of the higher valleys, of *roches moutonnées* or smoothly planed surfaces. Glacial striæ were not observed, having been obliterated by weathering.

All the upper portion of the Belt Mountains is covered with a dense forest composed of Douglas's and Engelmann's spruces, *Abies Douglasii*, and *A. Engelmanni*, the balsam fir, *Abies concolor*, and *Pinus contorta*. In places, the trees are heavily draped with tufts and streamers of the jet-black fibres of *Alectoria sarmentosa*; while many trees and particularly dry branches are decorated with bunches of the lemon-yellow *Evernia vulpina*. Lower down on the mountain are scattered trees of *Pinus ponderosa*.

The valley of Smith's River separates the Great Belt from the Little Belt Mountains. It is as picturesque and beautiful as the valleys on the north side of the mountains, but is quite different in aspect. The sides generally are smooth and unbroken slopes, 1500 feet or more in height, covered with rich grass and presenting no rock exposures. The summits of the hills are crowned with evergreens which here and there creep down the ravines, of which they occupy, in preference, the slopes having a northern exposure, because here the snow lies deepest and longest, supplying the greatest amount of moisture. The cause of the peculiar topography of the valley of Smith's River is to be found in its geological substructure, for it is cut all the way to Sulphur Springs, in Cambrian rocks, which form a series several thousand feet in thickness. They are mostly argillaceous shales or slates, which break down together and form gentle slopes.

Sulphur Springs is a well-built, handsome town, of several thousand inhabitants, gathered around hot springs which have a high reputation for their medicinal properties. From Sulphur Springs we crossed the southern extension of the Great Belt Mountains to the valley of the Missouri at Townsend. The range is here altogether composed of the Cambrian (?) slates which form the banks of Smith River,—probably the same series that is cut by the somewhat famous and picturesque Prickly Pear Cañon on the west side of the Missouri. In some places these slates are compacted by local metamorphism into masses of considerable hardness, but generally they are rather soft, fine grained argillo-silicious rocks, blue or gray in color, and finely laminated by planes of deposition. Occasionally a harder layer, an inch or two in thickness, is more silicious and rings like novaculite. These rocks have suffered no change which would obliterate fossils, and look as promising as any shales; but the most careful search failed to detect a single fossil in them, although specks of carbonaceous matter were often seen, and some shadowy outlines that suggest sea-weeds. There is little doubt that this is the same formation with that seen beneath the Potsdam in Little Cottonwood Cañon near Salt Lake City, and in the Cañon of the Colorado,—a formation considered Cambrian by King, Powell and Walcott, and which has yielded the latter a few fossils, but is universally barren and disappointing. It does not occur between the Potsdam sandstone and the granite in the Belt Mountains, for the same reason that the "Georgia slates" do not underlie the Potsdam in the Adirondacks, viz., because the Potsdam is a sheet of sea-beach, produced by a wide-spread, almost continental, depression of the land, or general elevation of the sea-level, which carried the shore-line inland beyond the areas where the Cambrian rocks had accumulated.

The valley of the Missouri about Gallatin, and for nearly 100 miles below, is very broad and fertile, and is generally occupied by farmers or stock-raisers. Wheat, rye, and especially oats are successfully cultivated, but mainly by irrigation. All the low-lands and the foot-hills of the mountains are covered with a fine growth of bunch-grass, blue-stem and grama, upon which cattle, sheep and horses are well sustained throughout the year. The winters are long and severe, but not more so than in Minnesota, and the snow-fall is somewhat less. The stock is not generally fed or housed, though it would be more merciful and probably more economical to provide some shelter.

The Rocky Mountains.

Helena, the capital of Montana, is a well-built and wealthy town of some 8,000 inhabitants, located in and about the mouth of Last Chance Gulch, one of the famous gold-camps in the time of placer mining.

The foot-hills of the first range of the Rocky Mountains, here and northward to the British line, are composed of the palæozoic rocks which surround the Belt Mountains. About Helena, they are generally limestones, somewhat metamorphosed, but not much broken up. The various ravines which lead to the Missouri valley, head in the granite rocks of the core of the range; and near these, the palæozoic series is very much disturbed. The granites, as well as some of the sedimentary rocks, are traversed by many mineral veins, some of which are auriferous and have furnished the large amount of gold that has been taken from the gulches. Most of the mineral veins are, however, silver-bearing, and these form a number of groups where there are, or will hereafter be, prosperous mining camps. At Wickes, twenty miles south of Helena, are numerous mines now success.ully worked, and a very extensive plant for the concentration and treatment of the ores by smelting and leaching. A branch of the N. P. R. R. runs up to Wickes, carrying coke and other supplies at so cheap a rate as to give success to enterprises which were before unprofitable. The ores worked are argentiferous galena, containing much blende and pyrites.

The limestone series in this valley is underlain by heavy beds of quartzite, which apparently represent the Potsdam sandstone.

Red Mountain, sixteen miles west of Helena, lies at the head of another valley similar to that at Wickes; but the quartzites are here less conspicuous; the limestones only becoming silicious and flinty at their base. Red Mountain is cut by an immense number of mineral veins, generally of small size,—from one to six feet in thickness,—but exhibiting a remarkable uniformity in direction and mineral characters. They are approximately parallel, apparently continuous through the mountain, stand nearly vertical, and carry argentiferous galena, gray copper, zinc-blende and pyrites. The veinstone is chiefly quartz, but in some places consists almost entirely of black hornblende. The ores generally carry from 25 to 100 ounces of silver, but the gray copper, which is the richest, contains from 200 to 2,000 ounces per ton. Systematic mining operations are just beginning here; and should a branch road be carried up to the mines, it would seem that they must be productive and profitable.

After passing Helena, the line of the Pacific Railroad soon turns into the mountains and crosses the first or main range, coming down on to the head waters of Clark's Fork and entering a broad and fertile valley, which has its chief center of population at Missoula. The western border of this valley is formed by the Bitter Root Mountains, part of the broad belt made up of the western ranges of the Rocky Mountain system. All these consist of granite, broken through in many places by eruptive rocks, and flanked by quartzites, slates and limestones, which probably represent the Cambrian, Silurian and Carboniferous systems. In the lowlands which lie between the ranges, there are basins of quite modern Tertiary rocks.

A few miles below Missoula the road crosses a series of deep ravines, spanned by bridges, one of which is 211 feet in height. The rock exposed here is all slate of Archæan or Cambrian age. Below this, the road closely follows the course of Clark's Fork, through one of the most picturesque valleys on the continent. The immediate banks of the river are often precipitous masses of limestone, above which the wooded mountains rise to the height of 3000 or 4000 feet. The course of the railroad is northwest, until it approaches within fifty miles of the British line. This great deflection is caused by the western ranges of the Rocky Mountains which are high and continuous until the vicinity of Pend Oreille Lake is reached. Here they fall off, and the road turns directly west through them. The lake is an irregular sheet of water, crescent-shaped and fifty miles in length ; set with numerous islands and surrounded with mountains, it is extremely picturesque. The mountains consist of granite, flanked by slate, quartzite and limestone, all much metamorphosed, but apparently the palæozoic series which is seen holding the same relation to the granite in so many places in Idaho and Montana.

The western range of the Rocky Mountains, like the eastern, is metalliferous, but to what degree is hardly known, because most of it is yet unexplored. Veins of argentiferous galena and auriferous quartz have been found in the vicinity of Pend Oreille Lake, and the already famous but greatly over-rated Cœur d'Alene mines lie a few miles south of the line of the road.

Forests of the Rocky Mountains.

The forest vegetation of the Rocky Mountains and the valley of Clark's Fork, is abundant and interesting. About Helena, are seen the trees which are characteristic of the Park and all the eastern flank of the Rocky Mountains. The round-leaved cottonwood, *Populus monilifera,* with willows, the buffalo-berry, *Shepardia argentea,* etc., flourish along the rivers ; *Pinus ponderosa* and Douglas's spruce in the foot hills ; on the mountain-sides, the narrow-leaved poplar and the aspen, (*Populus angustifolia* and *P. tremuloides*) Engelmann's spruce and the western balsam fir ; and *Pinus contorta* and *Pinus flexilis* on the mountain summits.

Immediately after passing the divide, however, the characteristic elements of the Pacific coast vegetation begin to make their appearance. Douglas's spruce becomes more abundant, and the trees grow larger, evidently feeling more at home, while the western larch (*Larix occidentalis*), the western arbor vitæ (*Thuja gigantea*), the western hemlock (*Tsuga mertensiana*), and *Pinus monticola*, never seen on the east side of the mountains, multiply until they constitute the greater part of the forest. The upper Columbia is the special home of the western larch and the mountain pine, though they extend westward to and on to the Cascade Mountains; but about the mouth of Clark's Fork they often constitute half the forest. The western hemlock begins here with small trees, which have the aspect and indeed all the characters of its eastern representative, of which it is in fact only a variety. In the moist and equable climate of the lower Columbia it acquires the greater size, smoother bark and more fine-grained wood, which are its distinguishing characters.

The interval between the Rocky Mountains and the Cascades is quite different in its topography, geological structure and vegetation from any region east of it. It is generally destitute of trees, though a few scattered yellow pines reach out from the Rocky Mountains on the one side and the Cascades on the other, along this line, and though not numerous grow to a large size.*

In a general way this is a plain, but the monotony of the surface is broken by a great number of low hills and knobs of black or brown basalt, the product of the volcanic eruptions by which the plain has been repeatedly flooded in Tertiary and

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* Further south this arid belt is the special home of this tree. One hundred miles south from the Columbia River, it forms continuous forests where the trees, rooted in the light volcanic soil, closely set, are often four, five or six feet in diameter. In these forests there is no other tree and scarce any undergrowth. Here and there a clump of *Cercocarpus* or red gooseberry is seen. The ground is usually bare, and so soft that horses sink into it to the fetlocks. The absence of animal life is also striking: one may travel through this forest an entire day and scarce hear the chirp of a bird or the hum of an insect; and yet the yellow pine is there in its glory, its huge, cylindrical trunk covered with large plates of cinnamon-colored bark, standing as they have done for ages waiting the advent of their insatiable enemy, the railroad man, who will some day split their trunks for ties and burn their branches for fuel; and the forests of yellow pine, like those of the redwood and white pine, will be gone from the face of the earth.

recent times. Between the rugged rock-masses are level spaces dotted over with bunch grass, sage (*Artemisia*), and *Linosyris.*

The geological substructure consists of a series of Tertiary beds of various kinds, sedimentary volcanic ash, washed down from the highlands, and diatomaceous earth, interstratified with sheets of basalt. It is evident that this belt was for a long time, either wholly or in part, occupied by lakes. During long periods of quiet, all forms of life were abundant; the land supported a varied growth of arborescent and herbaceous plants, which furnished food to a great variety of animals, while the water was inhabited by fishes and mollusks of many kinds. At intervals, however, showers of ashes, mostly emanating from the volcanic vents of the Cascade Mountains, covered the countay, destroyed, over large areas, all forms of animal and vegetable life, and washing into the lakes, formed strata many feet in thickness. At other times, floods of lava poured down into this valley, spreading over the land and the lake-bottoms, to be covered again in time with other sheets of stratified tufas, or by fresh-water fossiliferous beds.

The Columbia, Snake River, John Day's River, the Des Chutes, and many minor streams, cut deeply into this plain, and expose in their banks sections of the beds described. In the valley of the Des Chutes, cliffs 1,000 feet in height are formed of them; and about the Dalles, the remains of horizontal Tertiary beds are seen 2,000 feet above the present level of the Columbia. These show that the lofty and continuous chain of the Cascades formed a mighty dam, which kept back the drainage of the interior so that it formed a series of great lakes, bounded on the east by the Rocky Mountains, and on the west by the Cascades, and separated into several basins by the Blue Mountains and others of the desert ranges.

The accumulated water found an outlet to the sea through the lowest gaps in the Cascade Mountains. Of these, the most important was that where the gorge of the Columbia is now situated; others exist further south and are now traversed by the the Klamath and Pit River (Sacramento). In the Columbia basin, the old lakes are all drained, or filled, and their bottoms are deeply scored by the draining streams. The lake of the Klamath basin is now represented by the Klamath Lakes, Rhett Lake, Wright Lake, Goose Lake, etc., which occupy the points of greatest depression.

Though much of this great plain has the aspect of a desert, only a small portion of it is absolutely sterile. There is much prairie land covered with a continuous sheet of grass; and even the more sandy and rocky surfaces have proved to be fairly good grazing ground. It is also true that the attempts to cultivate the soil have been attended with unexpected success, and about Walla-walla, that which was supposed to be a desert surface is producing great crops of wheat.

The Cascade Mountains.

Although represented on most maps as an unbroken line of elevation stretching with an almost north and south course from the Californian to the British line, with its *hachures* looking like an enormously long hairy caterpillar, no just conception is thus given of this broad and compound mountain belt. It is continuous with the Sierra Nevada of California; and it would have been better if they had been designated by a common name. The mountain belt is in Oregon and Washington from thirty to fifty miles in width, consisting of a number of parallel ranges of which the highest is along its eastern border. This is crowned by a series of volcanic cones, Mt. Shasta, Mt. Pitt, Mt. McLaughlin, Mt. Jefferson, Mt. Hood, Mt. Adams, Mt. Rainier (Tacoma), and Mt. Baker, which range from 10,000 to over 14,000 feet in height, are all capped with perpetual snow, and form the most impressive group of mountains on the continent. From the California line northward, the material of which these mountain ranges are composed is mainly eruptive in character. The peaks mentioned, and many others, are volcanic vents of which the fires are not yet extinct, and some of them have been in active eruption within a few hundred years. Like the Sierra Nevada, this great fold in the earth's crust was formed after the Triassic and Jurassic, but previous to the Cretaceous age; and yet, like all other great mountain belts, it has been formed by many additions made at various times. In California, the range is largely composed of granite and other crystalline rocks of ancient date, flanked by slates which have been proved by the California geologists to be of Triassic and Jurassic age; while the

Cretaceous is deposited unconformably upon these, rising to the height of but a few hundred feet above the sea. North of the California line, the rocks forming the mountains, as has been mentioned, are almost entirely eruptive; and it is evident that this has been the theatre of more violent volcanic action than any other part of the continent known to us. Most of the eruptions took place in Tertiary times, as we know from the intercalation of the trap overflows with the Tertiary lake-sediments, many of which are store-houses of vegetable and animal fossils; but they have continued down to the present day.

Many years ago, when connected with Western Government Surveys, I followed these mountains from the California line to the Columbia, and at several points crossed lava streams which had flowed down the east flank of the Cascades, and were as fresh and ragged as the modern lava streams of Vesuvius. Not a particle of vegetation had attached itself to them, and it is certain that not a hundred years have passed since some of them were flowing.

Ancient Glaciers of the Cascade Mountains.

As has been stated, the Rocky Mountains, from New Mexico to British Columbia, abound in evidences of ancient glaciation. This is also true of the Uinta Mountains, the Wasatch, the Sierra Nevada and the Cascade Mountains.

In the group of five snowy peaks, called in Oregon the Three Sisters—because only three are visible from the Willamette Valley—miniature glaciers were found by our party in 1855 at the heads of McKenzie's Fork, and of one of the tributaries of the Des Chutes; and on Mt. Rainier a dozen or more have been described, some many miles in length. But all the glaciers and snow-fields now existing on the Cascade Mountains are utterly insignificant compared with those of the glacial period. Then every gorge was filled with snow and ice, the broader and more irregular summits were covered with glaciers, and these descended several thousand feet below the present line of perpetual snow. Now we find, over miles square, the rock-surfaces planed smooth or grooved like a plowed field, and every projecting crest of volcanic rock, rough and ragged as it was, is rounded over and worn into a *roche moutonnée.* From the Three Sisters the glaciers descended into the valley of the Willamette on the west and that of the Des Chutes on the east; and I traced with the barometer the glacial markings, from the snow-line to a point 2500 feet lower, where they pass under the alluvium of McKenzie's Fork.*

The Forests of the Cascade Mountains.

All the summits and western slopes of the Cascade Mountains are covered with a dense forest, mainly of evergreens, of which many of the trees are of gigantic dimensions. On the eastern slopes, the prairies in places run up the mountain sides, but the timber follows all the valleys down to the plain. East of the mountains are scattered trees of the yellow pine (*Pinus ponderosa*) and the western cedar (*Juniperus occidentalis*), and in some localities, as has been mentioned, groves and forests of the former. The evergreens which cover the mountains consist of four species of pine, viz., *Pinus Lambertiana*, *P. monticola*, *P. albi-*

* It has been claimed by Lecoq (*Les Glaciers et les Climats*), and following him, by Prof. Whitney and others (*Later Climatic Changes*), that the great development of glaciers during the Ice Period, such as those of the Canadian highlands, the Rocky Mountains and the Cascades, of which we have such abundant evidence, was not the effect of a *cold* period, but a *warm* one, which increased the precipitation and consequently the snow-fall, at all places where the temperature was low enough to cause it to take the form of snow. If this was all, however, the most extensive glaciers should be in the Alpine districts of the tropics or of the temperate zones, wherever the precipitation is most abundant and the temperature low enough to produce perpetual snow. But we have, on the summits of the Cascades, a demonstration of the fallacy of this view ; since here some of the mountains rise 14,000 feet and the line of perpetual snow is not over 7,000 feet, while the annual precipitation is greater than in almost any other portion of our country. In fact the snow accumulates in such quantity that, even in midsummer, it reaches so low that it is met and opposed by a vigorous forest growth, the product of a mild climate. It is evident that no elevation of temperature, though it should increase the evaporation on the Pacific and the rainfall on the coast, would cause the renewal of the ancient glaciers ; but with a depression of temperature which should continue the present winter conditions through the year, the precipitation remaining the same, the accumulation would soon cover the mountain summits with snow and ice and bring the glaciers down to their old limit.

caulis, and *P. contorta*. Of these, the first is the most gigantic species of the genus, attaining in its chosen habitat in this range of mountains, a height of 300 feet and a diameter of from 12 to 15 feet. *P. monticola* is much smaller, hardly equalling in dimensions its eastern representative, the white pine, but closely resembling it in general habit and minor botanical characters. On the mountains it is less abundant than in the valley of Clark's Fork, but attains somewhat larger size. This, with the sugar pine and white pine, constitute a well defined sub-genus, characterized by five-leaved and blue-green foliage ; fusiform, resinous, imbricated cones, hanging on the ends of a few large and high branches ; and in the character of the wood. Three firs, designating by that name those bearing erect cones with permanent axes and deciduous scales, are also common, viz., *Abies grandis, A. nobilis,* and *A. amabilis.* Of these, the first is the western balsam-fir, resembling our eastern balsam, but a more magnificent tree, attaining an altitude of 300 feet. The last two are remarkable for the magnitude of their cones, which are six inches in length and two and a half in diameter, the first decorated with reflexed and fimbriated bracts, the second purple in color and dotted over with resin. Four spruces, Douglas's, Menzies's, Patton's, and the hemlock, are there. Of these, the first is the largest and the most abundant, attaining an altitude of over 300 feet and a diameter of 10 feet ; Menzies's spruce (*Abies Sitchensis*) grows to a height of over 200 feet, and is generally as strict as a church spire ; the hemlock is comparatively rare on the high lands, and is only seen at its best in the valleys ; Patton's spruce (*Abies Pattoniana*) is a near relative of the hemlock, having the same feathery foliage, but that which is denser and richer. On the whole, it is in my judgment the handsomest of all the conifers. On some of the Alpine meadows among the snow mountains—especially the Three Sisters—are scattered individual trees or groups of two or three kinds of fir and spruce, which surpass in symmetry and graceful grouping any human achievement in the way of landscape gardening. Where the fir forests are most dense, the trees are so thickly set that two great trunks may generally be reached by the extended arms. No undergrowth occupies the ground, and the foliage of the firs is confined to the higher branches, which interlock to make a roof impenetrable by the sun's rays. Sometimes the gloom of these forests is further enhanced by gray or black lichens, which drape the trunks and hang from the dead branches like the Spanish moss, but producing a far more funereal effect. Where fire has run through these forests, the trees, killed but not consumed, and subsequently overthrown by the wind, form a labyrinth through which it is sometimes well-nigh impossible to force one's way. The ground thus open to the sunshine is soon covered by a dense growth of bracken (*Pteris aquilina*), which often reaches a height of from six to eight feet. After this or with it, comes Ceanothus or manzanita, with huckleberries and service-berries, which fruit so abundantly as even to tint the mountain sides with the black, purple or blue of their berries.

The larch, to which reference has already been made, is scattered sparsely over the eastern slope of the Cascades, and it here attains its maximum dimensions. The trunk is sometimes 200 feet in height, the branches relatively small, and the foliage fine and delicate in color, so that the larger trees look like lofty columns wreathed and decorated by climbing vines.

The hard-wood trees are few and insignificant as compared with the conifers. In the gorges and along the streams are the narrow-leaved and trembling poplars, and on the uplands the large-leaved maple and chinquapin (*Acer macrophyllum* and *Castanopsis chrysophylla*) ; the first is the only real tree-maple of the west coast. It attains a height of 75 to 80 feet, and the leaves, averaging six inches in diameter, on young plants are sometimes many times as large. The chinquapin, though usually a shrub, occasionally forms a handsome tree 30 to 50 feet in height, conspicuous for the contrast between the bright green of the upper and the golden yellow of the under surface of its leaves.

The Gorge of the Columbia.

This is one of the most impressive and interesting topographical features in all the picturesque West. It is cut with a nearly straight westerly course, across the whole breadth of the Cascade Mountains, fifty miles, and its banks rise from 2,000 to 4,000 feet directly from the river side. Most of the material of which the walls are composed is basalt. This can be seen to form distinct layers, the products of different overflows from the great volcanic vents north and south of it.. Cape Horn, a bold headland, shows a vertical face of trap nearly 500 feet in height.

No one who examines the gorge of the Columbia will fail to be convinced that it has been cut by the river. The general altitude of the mountains, in which there are no other passes lower than about 5,000 feet, as well as the altitude of the lake deposits on the eastern side, indicate that the work of cutting this channel began at a height of not less than 3,000 feet above the sea. At this time the river must have had a fall of at least this number of feet into the valley of the Willamette, and we must picture to ourselves a series of cascades of greater magnitude and more picturesque than any now known. This water-power was, however, busily engaged in cutting down the barrier; and in process of time this was so completely removed that a navigable canal was opened from the Dalles to the ocean. The western entrance to the gorge is now at tide-level, and the lower part of the river is, like the Hudson, an arm of the sea. It is true that at present the "Cascades of the Columbia" form a serious interruption to the navigation of the river, for they are produced by a dam 63 feet high, which fills the channel for three miles. But this dam, as we know, is of recent date, and has been caused by an avalanche from the sides of the gorge. Above it, the river is simply a long lake, and in low water a series of stumps and trunks can be seen coming up from below the water-level, which belonged to trees that could never have grown in the places they occupy, if the barrier of the Cascades had existed.

Steamboats navigate the Columbia from the Dalles down, with a transfer at the Cascades ; and this is much the better route to take for those who would get a good view of the gorge, with its imposing walls, its hanging forests and its picturesque waterfalls which leap 1,000 feet from the cliffs,—to say nothing of the old Indian burial-grove, and the multitude of silicified tree trunks at the Cascades. The railroad is built along the face of the southern cliff, high above the water, and although it gives only a one-sided view of the gorge, is generally chosen by travelers who prefer rapid transit to beauty of scenery.

The Lower Columbia.

The country bordering the Lower Columbia is too well-known to require detailed description. I am compelled, however, to refer to one or two points in its physical structure, which are of special interest when brought into connection with facts of similar import observed in the region about Puget's Sound. I have said that the Lower Columbia is an arm of the sea. It is in fact a deep river valley which has been flooded by an influx of the sea caused by subsidence. This brings the tide-water to the foot of the falls of the Willamette at Oregon City, and to the Cascades. It requires no argument to prove that such a channel could not have been cut unless by a rapid stream flowing into the ocean when it stood at a lower level. Whether the change in the relative level of land and sea here remarked was part of a general movement that produced the influx of the sea into the fiords which fringe the northern coast; and whether this is not a part of a still grander movement that flooded the old excavated valleys of the James River, the Potomac, the Schuylkill, the Hudson, the St. Lawrence and the Saguenay, and at the same time filled the fiords of the northeastern coast, are questions which cannot now be fully answered, but are worth considering.

It will be noticed that the general plan of the topography of this part of the coast is altogether similar to that of California; namely, the great wall of the Cascades, bordered on the west by the Willamette and Cowlitz valleys and the Coast Mountains, are re-produced further south by the Sierra Nevada, the great California valley, and the Coast Ranges; and their topographical features are not only physically similar, but are geologically identical,—the Cascades being the northern continuation of the Sierra Nevada, the more modern Coast Mountains following continuously the coast line; the great trough between them being essentially one, but filled, in its centre, by a mass of mountains.

The forests of the country bordering the lower Columbia are a physical feature that will strike every traveler with surprise and admiration. They are also of primary importance economically, since they form the basis of the most important industry of the northwest coast. They are mostly composed of evergreen trees which attain an altitude of 200 to 300 feet, and are crowded so closely that when an opening is made in the forest it seems surrounded by a wall of timber. These great forests stretch from the Californian to the British line on the summits and eastern flank of the Cascades, over all the Coast Mountains, and in the lowlands along the Willamette and the Cowlitz, and about Puget's Sound, with the exception of prairies that form part of the surface of the Willamette valley, and occupy limited areas about the Sound.

In southwestern Oregon and northern California are the famous redwood groves, the only place in the world where this magnificent tree (*Sequoia sempervirens*) grows in such numbers as to form forests. It extends in clumps and scattered trees far down the coast in California, and it does not reach the Columbia on the north, so that its range is quite restricted. About Port Orford and Humboldt Bay it is the principal timber tree, and in size it almost equals its gigantic relative, the mammoth tree of Calaveras County (*Sequoia gigantea*).*

At Port Orford one may see hundreds of redwood trees of which the trunks attain a diameter of 10 to 15 feet; but as the lumber and timber they furnish is of excellent quality, they are being destroyed at a rate that will soon exhaust the supply.

Along the Columbia and about Puget's Sound the principal trees are the Douglas and Menzies spruces, the balsam fir, the western arbor vitæ and the hemlock. In some localities, especially further north, two cypresses are abundant, the Nootka cypress (*Chamæcyparis Nutkaensis*) and the ginger pine (*C. Lawsoniana*). The latter is sometimes called the ginger pine from the fragrance of its wood. It is cultivated for its beauty and esteemed for the excellence of its lumber. Much less numerous, but widely scattered, is the western yew (*Taxus brevifolia*), often a handsome tree 50 to 60 feet in height. Along the river

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* Great scientific interest attaches to these two species of *Sequoia*, since they are the only representatives of the genus now living on the earth's surface, and are a relic of the grand forests which in Tertiary times covered all the northern part of this continent, and in which they were associated with other species of *Sequoia*, and with a multitude of other evergreen and deciduous trees, most of which have disappeared, but a few remain,—the tulip tree, deciduous cypress, magnolias, etc.,—which form the glory of our present forests.

sides are many cottonwoods (*Populus trichocarpa*), the Oregon ash (*Fraxinus Oregona*), and an arborescent alder (*Alnus rhombifolia*), which reaches an altitude of 60 feet, with a trunk-diameter of 12 to 15 inches. On the dryer and higher ground is found *Pinus ponderosa*, and on the lower, thickets of *P. contorta*, often growing like canes in a cane-brake. Scattered through this lowland forest are also the two arborescent maples of the west, *Acer macrophyllum* and *A. circinnatum*. Of these the latter, called the vine maple, is a peculiar feature in the forests of the Lower Columbia, Puget's Sound, and Vancouver's Island. It is rarely more than six inches in diameter, the trunks very slender, and several springing from the same root. These droop, and reaching the ground, frequently take root at the summit. Where these interlacing trunks are numerous, they form a thicket which is almost impenetrable. To this meagre list of angiospermous trees, I should add Garry's oak and the Madroña (*Quercus Garryana*, and *Arbutus Menziesii*). The oak, scattered about the open grounds of the Willamette Valley and Puget's Sound, occasionally attains a diameter of three or four feet, but with a spreading and irregular growth and brittle wood, so that it has little value as a timber tree. The "Madroña" is a small tree, but much admired for the beauty of its foliage, and the peculiarity of its bark. The former is persistent and rich, and the latter exfoliates in brown and greenish layers of different shades.

The undergrowth of the Pacific coast forest, where the latter is not too dense, is abundant and varied. Over the rocks and fallen tree-trunks is a thick mat of mosses, which grow with a luxuriance and exhibit a variety nowhere rivalled in the eastern States. Ferns are less numerous than might be expected in this moist climate, but a few species are abundant and grow with great luxuriance. The most common is the cosmopolitan bracken (*Pteris aquilina*), the next, *Aspidium munitum*, strikingly like our eastern *A. acrostichoides*, but having a much stronger growth. Of the less numerous species, a respectable list could be made, but on the whole the ferns are not an important element in vegetation. Of the under-shrubs, the most striking is *Fatsia horrida;* this has the aspect of an *Aralia;* it has a thick woody stem six to ten feet long, somewhat decumbent at base, but bearing above a number of large palmate leaves. Both stem and leaves are very prickly, and it is a common but probably ungrounded belief that its spines are highly poisonous. A large shrubby *Spiræa* (*S. Douglasii*) grows six to ten feet in height, with numerous large open panicles of inconspicuous flowers. Several species of *Ceanothus* abound, the most common being *C. velutinus*, which forms dense thickets. *Lonicera involucrata*, conspicuous from its black *belladonna*-like fruit, surrounded by large persistent purple involucres, is found along the streams, with one of the most showy of all the Oregon shrubs, *Cornus Nuttallii*, Audubon, the western representative of our dogwood. Usually it is smaller, but occasionally becomes a tree 50 feet in height. The flower-like calyces are large, white, and less crumpled than those of the eastern tree.

More interesting than these to botanists, as well as to the general public, are the fruit-bearing shrubs, the "Salal," (*Gaultheria shallon*,) the Oregon grape (*Berberis aquifolium* and *B. pinnata*), and the "salmon-berry," (*Rubus spectabilis*). Of these, the first covers the ground over great areas with its creeping or decumbent stem, its broad, oval, shining leaves, and its pendent, black and edible fruit. The two species of *Berberis*, so well known under their old name, *Mahonia*, are low shrubs, with pinnate, spiny leaves, yellow, clustered flowers and blue bloom-covered acid berries. They are not unfrequently cultivated as ornamental plants in the eastern States. The salmon-berry takes its name from the color of the fruit, which resembles that of the flesh of the salmon. It is a tall, strong-growing raspberry, with conspicuous purple flowers and large ovoid fruit, much esteemed by the Indians, but rather insipid. *Rubus Nutkanus*, the white variety of our flowering raspberry, is everywhere common, with the precise habit of its eastern representative.

Surface Geology of the Puget's Sound Basin.

The name Puget's Sound is, in popular use, made to cover all the peculiar group of inlets and tideways which lie immediately east of Vancouver's Island,—Puget's Sound proper, Admiralty Inlet, Hood's Canal, etc. These occupy the northern extension of the great Columbian valley, which, like its counterpart in California, lies between the Coast ranges and the Cordilleras. Further north still, this depression is deflected toward the northwest by a change in the direction of the Cascade Mountains, and of the representatives of the Coast ranges on Vancouver's Island, is mostly occupied by water, and is known as the Gulf of Georgia. In Washington Territory the Coast Mountains are higher than in Oregon, and have received the local name of the Olympian range, of which the highest summit is called Mt. Olympus. This range terminates somewhat abruptly, but is apparently continued in the mountains of Vancouver's Island. Through the gap between these and the Olympian range a deep channel is cut, now an arm of the sea, called the Strait of Juan de Fuca. In former times, when this portion of the continent, and probably the whole northwest coast, stood higher above the ocean, this strait was the valley of a great river, which drained most of the western slope of the Cascades in Washington Territory, and had as branches the Skagit, Snoqualme, Dwamish, Puyallop, Nisqually and various minor streams. During the ice period, this hydrographic basin was filled with a great glacier made up of contributions from all the surrounding mountains. It flowed out to sea by the Strait of Fuca; but this channel was far too narrow for it, and it spread all over the southern portion of Vancouver's Island, planing off, rounding over or deeply scoring the rocks in its passage, and leaving its autograph so plainly written that he who runs may read.

As the glaciers retreated, they left behind a sheet of drift several hundred feet in thickness,—partly waterworn and stratified, partly unstratified boulder clay with striated pebbles. These drift deposits formed a plain of which the surface was nearly level. In process of time, the draining streams had cut in this plain a series of valleys all tributary to one which led out through the Strait of Fuca to the ocean. After perhaps some thousands of years, during which the excavation of these valleys progressed, a subsidence of the land or rise of the water-level caused the sea to flow in and occupy the main valley and all its tributaries up to the base of the mountain slopes. Such in few words is the history of the formation of this remarkable system of inlets. They are simply the flooded valleys of a great river and of the branches which formerly joined it, but which now empty into the extremities of the finger-like inlets that have partially replaced them.

There are but few localities in the Puget's Sound basin where the rocky substratum rises so as to be visible above the water-level. Along the northern and western margin of Vancouver's, Sucia, Orcas and Whidby Islands, and at Chuckernuts and Sohorne the rock appears, but at Tacoma, Steilacom, Seattle, Port Madison, Port Townsend, and it may be said generally about the Sound, the shores are steep bluffs, 100 to 150 feet in height, composed of drift alone. From the cliffs at Port Richmond and Tacoma, I took sub-angular scratched and ice-worn pebbles, as characteristic and convincing as any to be found in the boulder clay of the eastern States.

The subsidence which caused the sea-water to flow into the subaerial excavated valleys of Puget's Sound, filled also the channel of the Columbia to the Cascades, and the system of fiords that fringe the northwest coast, of which these are representatives.

We have evidence, too, that the area occupied by the sea was at one time much more extensive than now, for all the country immediately about Puget's Sound is marked with a series of marine terraces which Mr. Bailey Willis, who studied them when connected with the Transcontinental Survey under Prof. Pumpelly, tells me can be traced to a height of 1,600 feet above the present ocean level. These terraces are conspicuous on the low divide which separates the valley of the Cowlitz from the basin of Puget's Sound ; and here, as over much of this region, the ground is covered with pebbles and waterworn boulders, the product of the long-continued dash of the shore waves on a slope composed of drift materials. In the advance and recession of the shoreline, the finer materials have been mostly washed away, and the stony surface has little agricultural value. Fortunately it is well adapted to the growth of trees ; and the splendid forest which covers it is perhaps an equivalent for all it has lost. The facts here given show why the cultivation of the soil in Washington Territory is limited to the narrow belts of modern alluvium along the streams, and indicate that the fisheries, coal-mining, and lumber industry must be in the future, as they are now, the most important sources of wealth.

Geological Substructure.

The sheet of drift which has been described covers most of the lowland, and conceals the underlying rocks so that they appear only about the margin of the basin. The foot-hills of the Sierra, like the more elevated portions, are composed chiefly of eruptive rocks; but at various places along the northern and eastern margin of the basin, the drainage streams have exposed sedimentary strata. These are all Cretaceous or Tertiary. On Queen Charlotte's Island, as we learn from the Canadian geologists, are Lower Cretaceous rocks, very much disturbed, but containing beds of lignite converted into anthracite, and many mollusks which apparently represent the Neocomian of the Old World.

On Vancouver's Island, the granites and old metamorphic sediments are succeeded by Upper Cretaceous strata, which contain several valuable seams of coal that have been worked for many years. Specimens of the fossil plants and mollusks associated with these beds, were sent by Mr. George Gibbs to the writer in 1858. Among the former were *Inoceramus* and *Baculites*, which gave the earliest information of the Cretaceous age of these deposits. Descriptions of some of the fossil plants were published by the writer in the Proceedings of the Boston Society of Natural History for 1863. On Orcas and Sucia Islands are also exposures of Cretaceous rocks which abound in fossils.

On the east side of the basin, coal outcrops at several points, and has been worked at Bellingham Bay on the Skagit River, at Newcastle, Carbonado and Wilkinson. At Carbonado the coal-bearing rocks, turned up at a high angle, are cut across in a cañon formed by Carbon River, and a very satisfactory view is here obtained of the structure of one of the local basins. The series is several thousand feet in thickness; and in this section nine workable seams of coal are exposed. At Wilkinson and in that vicinity, Mr. Willis made a careful exploration of another basin, which also includes several beds of coal and some thousands of feet of associated rocks. From these localities and others further north, large collections of fossil plants have been made by the writer and his assistant, Mr. Edward Lorrance. These represent a rich and interesting flora of Upper Cretaceous and

Tertiary ages, of which figures and descriptions will be published by the U. S. Geological Survey.

Modern Glaciers of the Sierra.

From the Willamette Valley and Puget's Sound, splendid views are obtained of the great snow-peaks of the Cascade Mountains,—the Three Sisters, Mt. Jefferson, Mt. Hood. Mt. Adams. Mt. St. Helens, Mt. Tacoma and Mt. Baker. Of these. Mt. Hood has an altitude of 11,225 feet, Mt. Adams 12.250, and Mt. Tacoma 14,400. In Colorado and California are a number of summits of equal absolute height, but they have nothing like the relief above their surroundings that these have, carry far less perpetual snow. and are in every way less impressive. In Washton Territory, the permanent snow-line on the west side of the mountains is about 6,500 feet, on the east side several hundred feet higher. Mt. Tacoma carries, therefore, about 8,000 feet of snow. Below this it is covered with a dense forest. Its foothills nowhere rise to the height of 2,000 feet above the sea, and hence are invisible at a distance; so from many places about the Sound, practically the whole of the mountain is seen in one view,—a gigantic cone 14,000 feet in height, apparently rising directly from the sea-level! Mt. Shasta has the same altitude, and as seen from Scott's or Strawberry Valley, is wonderfully impressive; but it is situated further inland and further south, its base is higher and it has less snow, and it is therefore somewhat less imposing. Mt. Hood, as seen under favorable circumstances from Fort Vancouver, especially when reflected from the lake-like surface of the Columbia, is as beautiful but far less grand. It is not too much to say then, that no other mountain on this continent, and none in Europe, rivals in grandeur and beauty Mt. Tacoma; and it is doubtful whether in the world there is any that produces a greater impression upon the beholder.

Though appearing in the distance so symmetrical and smooth, Mt. Tacoma has been found to be a ragged and compound mass consisting of three conspicuous summits, and many subordinate peaks, with precipices of 2,000 to 3,000 feet in height, and deep gorges which make the ascent difficult and even dangerous. It has been ascended, however, several times, and its labyrinths sufficiently explored to prove that it carries from eight to twelve glaciers, some of which are many miles in length and will bear comparison with those of the Alps.

Every traveller who enters the Puget's Sound region from the south, is sure to be struck by the turbid, milky appearance of the water of the Cowlitz River, along which the railroad runs for miles. This character it shares with all streams which drain glaciers, and has caused the Swiss mountaineers to give to the water of such streams the name of "*Gletscher Milch.*" This turbidity is due to the sediment produced by the constant grinding action of these enormous masses of moving ice, set with stones, upon their beds, and attests the sometimes disputed efficiency of glaciers as eroding agents. The Puyallop, White River, and other streams which come down from Mt. Tacoma, are alike milky, and each shows that one or more glaciers are continually grinding away at its head. On the contrary, the streams which do not come from glaciers and are supplied by rain only and that filtered through the decaying vegetation of the dense forests, carry very little sediment, and that chiefly carbonaceous matter. These are clear but brown, and the contrast which the water of such streams presents to that of the rivers which drain the glaciers, is very striking, justifying the names borne by two such, of Black and White Rivers.

It has been contended by some writers, as before mentioned, that the extension of glaciers in former times was due simply to an increase in the amount of precipitated moisture; but it is easy to see that the heavy rainfall of Washington Territory might be increased indefinitely with no considerable elongation of the glaciers. But even with the rainfall remaining as it is, if a depression of temperature should take place, carrying the present conditions of winter through the year, the glaciers would soon creep down into their old beds, fill all the valleys of their draining streams, and finally coalesce to form one grand glacier which would flow out through the Strait of Fuca to the ocean.

Following the coast northward from Puget Sound, we find the glaciers coming down lower and lower, until in Alaska they reach the sea-level. No one can claim that this is because the precipitation is greater there, since observations show that it is not; but the careful observer must surely recognise that it is because at the north the temperature is lower. He must also accept these facts as a demonstration *that the prime factor in the production of the phenomena of the Ice Period, was a secular depression of temperature:* that it was a period of cold and not of warmth.

XII.—*Description of a New Species of Bird of the Genus Engyptila, with Notes on two Yucatan Birds.*

BY GEORGE N. LAWRENCE.

Read October 26, 1885.

Engyptila vinaceifulva.

The front is of a pale vinaceous white, the hind part of the head and the hind neck, are of a rather light reddish vinaceous, the hind part and the sides of the neck are glossed with very pale crimson, only perceptible in certain lights; the feathers of the back are of a light tawny, ending largely with a very pale tawny-white; the feathers of the rump and upper tail-coverts are of a darker and brighter tawny than the back, with lighter-colored margins; the two central tail-feathers are of a warm tawny color for half their length from the base, the terminal portion being very much lighter in color with a grayish cast; the shafts of these are white; the other tail-feathers are light tawny-brown, their outer margins narrowly edged with whitish, and their ends terminating with white having just a tinge of tawny; these have their shafts tawny-white; the smaller wing-coverts are in color much like the rump; the middle and larger coverts are lighter and warmer in color; the quills are of a light brownish-tawny, with their ends and outer margins whitish, the shafts are light tawny in color; the under wing-coverts are bright cinnamon red, and the inner margins of the quills are very pale cinnamon; the sides of the head are colored much like the front; the chin is pure white; the throat and upper part of the breast are light vinaceous, the lower part of the breast is of a lighter shade of the same color; the abdomen and sides are of a very pale warm tawny color; in the middle of the abdomen there is a spot of silky white feathers; the under tail-coverts are white, with just a tinge of tawny; bill black; tarsi and toes yellowish flesh-color.

Length, skin, $10\frac{1}{2}$ inches: wing, $5\frac{1}{2}$; bill, $\frac{5}{8}$; tarsus, $1\frac{1}{16}$.

Habitat. Temax, Yucatan. Type in my collection.

Remarks.—This does not resemble any other member of the genus, and is a most delicately colored species. It is another of the discoveries of Mr. Geo. F. Gaumer in Yucatan, who has kindly presented me with the type.

The coloring of some of the feathers has somewhat the appearance of being due to partial albinism; but I think they are of normal color, and I consider it not to be in an immature stage of plumage.

Mr. Gaumer's account of it seems to preclude the possibility of the whitish colors of this species being caused by albinism. He writes: "I have recently added several species to the Yucaton list, the most important of which, is a dove called the *Cancab.* I have been told about this dove a great many times in past years, but it has never been my good fortune to capture a specimen until a few days ago. It is the size of *L. albifrons.* The specimen taken is in immature plumage; there were two, but when I shot the one the other escaped, but I hope soon to get another."

Notes on YUCATAN BIRDS.

Engyptila fulviventris, Lawr.

I received from Mr. Gaumer three specimens of the pigeon I described as *Leptoptila fulviventris* (Ann. N. Y. Acad. Sci., Vol. II, p. 287). The generic name of this group of pigeons has been changed to *Engyptila.*

I pointed out (*loc. cit.*) wherein it differed from *E. albifrons*, but Mr. Salvin (Proc. Zool. Soc., 1883, p. 434) considers it not to differ from that species, under which he puts it as a synonym, and remarks as follows: "These Yucatan birds have the rufous tint of the underparts slightly darker than is usual in Guatemalan examples; but the difference is too slight to be considered of specific value."

My opinion of its distinctness has been fully confirmed by the further comparison of the specimens now received, with examples of *albifrons* from Guatemala and also from Yucatan, whence I have specimens not differing from Guatemalan ones.

I sent an example to Mr. R. Ridgway, of the National Museum, Washington, requesting his opinion ; he wrote as follows : "*Engyptila fulviventris* I should regard as distinct. We have one just like yours. It was obtained at Merida, by Schott, Jan. 17, 1865 ; besides, I have compared them both with a series of 31 adult examples of *E. albifrons*, and find none intermediate."

In my original description I say : "Fore part of the head of a pale bluish-white," this is not of so clear a color nor so well defined as in *albifrons*, and has a vinous tinge ; the tail-feathers are narrower than those of *E. albifrons*, and the white at their ends less in extent ; the chin in *E. albifrons* is pure white, in the other tinged with vinous ; the examples last received have their backs of a lighter shade of olive than in *albifrons*, instead of "rather darker" as in the description of the type, perhaps the difference may be seasonal.

Chætura Gaumeri, Lawr., Ann. N. Y. Acad. Sci., Vol. II, p. 245.

I have received from Mr. Gaumer three more specimens of *C. Gaumeri*, one having the spines unworn, in which state I have been desirous to get it.

He writes of this species as follows : "I have several specimens ; none of them have the spines so long as *C. Yucatanica ;* of this latter species I have one more specimen. *C. Gaumeri* lives in wells with rocky walls, hence the worn appearance of the spines."

One specimen now sent is the first I have seen with perfect spines. The rocky character of the places they inhabit, accounts satisfactorily for the worn condition of the spines in most of the specimens obtained.

The central spines of *C. Gaumeri* are in length,			- 0.13 in.
The shortest outer do.	do.	do.	- 0.5 "
The central ones of *C. Yucatanica*, are do.			- 0.20 "
The outer ones,	do.	do.	- 0.13 "

XIII.—*Characters of Two supposed New Species of Birds from Yucatan.*

BY GEORGE N. LAWRENCE.

Read November 23, 1885.

Polioptila albiventris.

Male. Front and crown of a glossy jet black, this color extending on the sides of the head as far as upon a line with the middle of the eye; entire upper plumage of a clear light plumbeous; two middle tail-feathers black; the first outer tail-feather is white, black on the inner web for a short distance from the base, the next is black for half its length, with the terminal portion white, the third feather is black for most of its length, ending with white, the fourth feather is black tipped with white; the primaries and secondaries are blackish-brown, very narrowly edged with white; the tertiaries are of the same color and have broader white margins; the under wing-coverts are white; third and fourth quills longest and equal; the under plumage is entirely white; the feet are dark plumbeous; the bill black.

Length, 3 75 inches; wing, 1.85; tail, 1.75; tarsus, .75; bill, 40.

Habitat, Temax, Yucatan. Type in my collection.

Remarks.—Mr. Gaumer sent a single specimen of this species, which he thought might be *P. nigriceps.* It differs however from that species in being smaller; in the black of the crown being more restricted, not extending on to the occiput; and in the color of the upper plumage, which is of a clearer and lighter plumbeous, while its under plumage is of a purer white.

Chætura peregrinator.

The upper plumage is smoky-black; the rump and upper tail-coverts are dark ash-color, the feathers of the latter with a very narrow edging of whitish; the tail-feathers are blackish-brown, with their shafts black; the wing-coverts are colored like the back; the quill feathers are black and have the margins of the inner webs of a brownish color; the lores are black; the chin and throat are grayish-white; the abdomen, sides and under tail-coverts are light fuliginous, darker on the latter; the bill and feet are black.

Length, 4.63 inches; wing, 4.38; tail, 1.75; middle spine, 0.15; outer, 0.10.

Habitat, Temax, Yucatan. Type in my collection.

Remarks.—Differs from *C. Gaumeri* in being somewhat larger and in having the quill-feathers much broader; the upper plumage is darker, the rump of *C. Gaumeri* is of a clear ash-color; the breast, abdomen and under tail-coverts are darker in the new species, more fuliginous.

Mr. Gaumer writes concerning it as follows:—

"On the 12th of September, at 4 o'clock P. M., a flock of about 150 swallows seemed to have recently arrived in Temax. They were evidently strangers, as they went at once to hunt for a suitable well (*senote*) in which to pass the night. They entered several, and at last selected one in the suburbs of the town, that was in daily use. They were very quiet and all entered the well at 5.30 P. M. I put some boys to work to catch them, and thirty-two good specimens were caught; of these I send you twenty tails and one entire bird. Next day they were all gone; and the *C. Gaumeri,* which is resident, was abundant as usual; five were secured, but all had their spines shorter and blunter, and all seemed to be at home, and not wearied as those of the day before."

As will be seen by Mr. Gaumer's account, the region usually inhabited by this species is unknown, its appearance in Temax being a transient one.

The spines on the tail-feathers of all the specimens sent are in good condition, whereas in nearly all of those of *C. Gaumeri* received they are worn off.

XIV.—*On Remarkable Copper Minerals from Arizona.*

BY GEORGE F. KUNZ.

Read October 5, 1885.

Some of the recent output at the Arizona copper mines equals in beauty any heretofore found in the United States, and these mines bid fair to outrival the world in the perfection of their mineral yield. Among the principal varieties are azurite, malachite, chrysocolla, native copper, and cuprite. Although the azurites are not equal to the finest from Chessy, still they do not appear to disadvantage in the comparison. The malachite is not abundant, but considered as single specimens, it is hardly inferior to that from Siberia.

Malachite.

This mineral, from the Copper Queen mine at Bisbee, Arizona, in beauty and thickness of vein almost equals the Russian. One mass, in particular, weighing 15 lbs., would furnish a magnificent table-top of no mean dimensions. Its measurements are: Length, 20 cm.; width, 15 cm.; height, 15 cm. It is covered throughout with mammillary protuberances measuring 35 mm. Among other pieces of peculiar interest, one, weighing 14 lbs., has a vein several inches in thickness and a surface roughened with mammillary knobs, the result of radiations 2.5 cm. across. On this there is a stalactite projecting as much as 10 cm., and from 2.5 to 4 cm. in diameter. Another specimen with a mammillary surface has a dozen stalactites, measuring from 10 to 20 mm. in diameter, and 5 cm. in height. We also have malachite in seams, 7.5 cm. thick, and sometimes 30 cm. square, covered on both sides with mammillary tufts of malachite, so compact as readily to admit of a polish. In addition to these, there are wonderful pockets of transparent calcite and malachite, measuring 10 to 20 cm. in width, filled with tufts of brilliant green, transparent, acicular crystals of malachite from 5 to 10 mm. long, grouped with beautiful flat nail-head crystals of calcite, also transparent, measuring 35 mm. in width.

In some instances, groups of these malachite crystals nearly 25 mm. across, penetrate the pellucid calcite, forming one of the most beautiful of mineral combinations, a malachite counterpart to the native copper in calcite from Lake Superior.

Malachite from the Copper Queen mine, forms thick crusts and seams, geodes and cavities over one foot across, and entirely made up of fine acicular, velvety crystals—these often two to four mm. long—the whole surface presenting the rich sheen of a green plush velvet. No locality has furnished finer specimens of this form.

AZURITE.

Azurite from the Clifton mines, Graham County, Arizona, and also from the Longfellow mine, occurs in beautiful groups from 1 to 12 mm. in diameter, and of a dark blue color. One form of the larger crystals is O. 1^2. I.

One spherical group radiating from a centre in all directions, consists of crystals 20 mm. long and 7 mm. thick, partially altered to malachite on the surface. Indeed, this mineral is here found in all stages of transition, some entire groups in large crystals being completely altered to malachite. Perhaps the finest group of azurite ever found on this continent is included here, measuring 25 cm. in height and 7.5 to 15 cm. across. It is covered on both sides with brilliant dark blue crystals from 5 to 12 mm. long. Very interesting perfect spheres of azurite are found here, composed of small crystals, and associated with beautiful spheres of malachite, pseudomorph after azurite.

Azurite coated with malachite was observed, and beautiful groups of perfect spheres 15 mm. in diameter, and of a rich Berlin blue color. Azurite from the Copper Queen mine is usually in the form of small crystals from .5 mm. to 5 mm. across, in delicate druses, or in compact mammillary masses about 12 mm. thick, or in radiations.

CHRYSOCOLLA.

This mineral is found of a beautiful turquoise-blue or greenish blue color, and containing cavities 3 to 4 cm. across, filled with thin layers of chalcedony and druses of quartz, which together form a compact coating over it. These cavities are often 7.5 cm. across, and of remarkable beauty. The quartz and chalcedony are thick enough to be susceptible of a polish, or the gangue can be cut with it, and thus a curious and attractive gem-stone can be made. The handsomest mineral of this description comes from the Old Globe mine in Gila County.

Chrysocolla, in beautiful blue patches 1 to 2 cm. across, occurs in an impure black oxide of copper, making an exceptionally rich combination. The handsomest form, however, (and perhaps no finer was ever found,) is the glassy-green chrysocolla from the Clifton district. It is filled with transparent green flakes 25 mm. long, 6 mm. wide, and 3 mm. thick, and penetrated by tubular hollows like the centres of stalactites. Another form consists of dark blue or bluish-green surfaces, from 7.5 cm. to 25 cm. across, only as a thin coating. This is equal in beauty to that from any other known locality.

Cuprite.

This species occurs in brilliant red crystals of cubic form, measuring from 1 to 5 mm., in groups of several dozen crystals embedded in massive cuprite and associated with native copper, from the Clifton group of mines, Graham Co., Arizona. It is also found in very dark cochineal-red crystals, almost black in fact, associated with malachite and calcite. One fine cube, coated with acicular crystals of calcite, measures 8 mm., and one fractured crystal 10 mm. One group, 3.5 cm. by 6 cm., consisting of several hundred crystals, principally elongated cubes from 1 to 3 mm. wide, has, in addition to the elongated form, crystals of the simple octahedron, the cube, and dodecahedron, and the cubo-octahedron and dodecahedron combined. The crystals from the Copper Queen Mine are from .5 to 1 mm. in size, and are simple octahedrons sharply defined, of a deep red color, implanted on malachite coated with limonite.

These crystals are usually white, but the color is due to a film which can be easily removed by washing.

Dioptase is obtained in beautiful bluish-green crystals 5 mm. in diameter, from the Clifton District; also native copper of a branching coralloid form, in groups of indistinct crystals, beautified by a red amorphous coating of cuprite, often 1 to 2 mm. in thickness, which is again enveloped in a thin white coating of kaolin, or, as is frequently the case, with an alteration of malachite after cuprite; in both instances the cuprite and copper protruding through the other coating.

Aurichalcite, from Copper Queen Mine, is found lining and covering cavities from two inches to seven and eight across (5 to 20 cm). It forms beautiful tufts and radiations of a light green, and bluish green color, or is also associated with opaque white calcite crystals in limonite cavities. The crystals, in the tufts, are from 2 mm. to 4 mm. high, and for beauty of association rival anything yet found.

Cerusite is abundant at the Flux Mine in Pima Co., where it occurs in wonderful masses and veins of a pure snowy white color. Solid blocks are taken out a foot square, and weighing from 50 to 60 lbs., made up entirely of crystals from 1 to 4 cm. in length, although the form is not distinct, except in occasional cavities.

One interesting group 10 cm. square is beautifully tinted with green by a deposit of carbonate of copper. The crystals are very perfect but indistinct. In respect to quantity of material these specimens are unsurpassed.

At the Belle Mine, Yavapai County, cerusite is also plentiful, but is not so white, and usually covered with a brown coating.

I am indebted to Messrs. Adams, Shaw and Nivens for information and specimens.

[All these mineral varieties were illustrated with a large set of very elegant specimens.]

XV.—*A Review of the North American Species of Petromyzontidæ.*

BY DAVID S. JORDAN AND MORTON W. FORDICE.

Read December 21, 1885.

[*With an additional note on the Lamprey of Cayuga Lake.*

BY SETH E. MEEK.]

In the present paper we have attempted to give the synonymy of the Lampreys of North America, with analytical keys by which the species may be distinguished. The specimens studied belong to the Museum of the Indiana University, while numerous others belonging to the United States National Museum have also been examined.

The North American species fall naturally into two groups, which it seems most suitable to regard as genera; although in both groups there are large anadromous forms with strong dentition and small fluviatile forms with the teeth less specialized,—modifications which may indicate subgenera. These genera may be defined as follows:—

ANALYSIS OF GENERA OF PETROMYZONTIDÆ.

a. Supraoral lamina ("maxillary tooth") contracted, composed of two or three cusps placed close together; discal teeth numerous, in concentric series; anterior lingual tooth with a median depression or groove; buccal disk large in adult (contracted in young).

PETROMYZON, 2.

aa. Supraoral lamina very large, expanded laterally, forming a crescent-shaped plate, with a cusp at either end, and sometimes a median cusp; anterior lingual teeth serrate more or less.

AMMOCŒTES, 3.

To these may be added a third genus, BATHYMYZON Gill, which is said to differ from *Petromyzon*, in having "the suproral and infroral plates or laminæ destitute of odontoid tubercles, the armature of the lamprey type being obsolescent."

This genus is probably valid, unless its characters be due to mutilation; as the "teeth" in all lampreys are readily lost in badly preserved examples.

Genus I.—BATHYMYZON Gill.

BATHYMYZON Gill, Proc. U. S. Nat. Mus., 1883, 254 (*bairdi*).

1. BATHYMYZON BAIRDI.

Petromyzon (Bathymyzon) bairdi Gill, Proc. U. S. Nat. Mus., 1883, 254 (Gulf Stream, Lat. 49°, at a depth of 520 fathoms).
Bathymyzon bairdi Jordan, Cat. Fish. Waters N. A., 1885. 4 (copied).

Habitat.—Bassalian fauna of Atlantic.

This species has not been described, further than that it is "closely related to *P. marinus*."

Genus 2.—PETROMYZON.

PETROMYZON (Artedi) Linnæus, Systema Naturæ, Ed. X., 1, 1758, 230 (*marinus*).
ICHTHYOMYZON Girard, U. S. Pac. R. R. Expl., 1858, 381 (*castaneus*; *hirudo*, etc.).
SCOLECOSOMA Girard, U. S. Pac. R. R. Expl., 1858, 385 (*concolor*, etc.).

ANALYSIS OF SPECIES OF PETROMYZON.

a. Anterior lingual tooth divided into two by a median groove; dorsal fin continuous, with a broad notch; fluviatile species of small size. (*Ichthyomyzon* Girard.)

b. Supraoral lamina (maxillary tooth) tricuspid; some of the lateral teeth bicuspid. Infraoral lamina (mandibulary plate) with 7 to 12 cusps; head 9 in length. - - - - - CASTANEUS, 2.

bb. Supraoral lamina bicuspid; infraoral lamina with 7 cusps; teeth on disk in about four concentric series; all of them simple; origin of dorsal nearly midway between tip of snout and end of tail; body more compressed than in other lampreys; head 7½ in length; depth 12; 51 muscular impressions between gill-openings and vent; color silvery, bluish above, often mottled; a small bluish spot above each gill-opening, usually conspicuous even in the larvæ; similar spots scattered along sides of back. - - - CONCOLOR, 3.

aa. Anterior lingual tooth with a deep median groove and terminating in an incurved point; dorsal fin divided; species of large size, anadromous (*Petromyzon*).

d. Supraoral lamina bicuspid ; infraoral lamina with 7 to 9 cusps ; teeth in obliquely transverse rows, 4 to 7 in each row ; the lateral teeth on each side of mouth bicuspid, the other teeth simple ; head and disk large ; dorsal fins low, well separated ; 64 muscular impressions between gill-openings and vent ; back with an elevated fleshy ridge anterior to dorsal fin (in males ?) in spring ; color bluish brown, mottled with blackish confluent patches, rarely nearly plain, dull brownish white below. - - - - - MARINUS, 4.

2. PETROMYZON CASTANEUS.

Ichthyomyzon castaneus Girard, U. S. Pac. R. R. Surv., 1858, 381 (Galena, Minn). Gunther, Cat. Fish. Brit. Mus., VIII, 1870, 507 (copied); Bean, Proc. U. S. Nat. Mus., 1882, 117 (Forlorn Hope, Louisiana).

Petromyzon castaneus Jordan & Gilbert, Synopsis Fish, N. A., 868, 1883 (name only). Jordan, Cat. Fish. Waters N. A., 1885, 4. Cragin, Bull. Washburn Coll. Lab., Topeka, Kas., 1885, 99 (Mill Creek, Shawnee Co., Kas.).

? *Ichthyomyzon hirudo* Girard, U. S. Pac. R. R. Surv., 1858, 382 (Fort Smith, Arkansas). Günther, Cat. Fish. Brit. Mus., 1870, VIII, 507 (copied). Bean, Proc. U. S. Nat. Mus., 1882, 119 (original type).

? *Ammocœtes hirudo* Jordan, Man. Vert., Ed. 1, 1876, 350 (in part).

? *Petromyzon hirudo* Jordan, Cat. Fish. N. A., 1885, 4.

Habitat.—Mississippi Valley.

Of this species, only the above-named examples are known. Thus far it appears to be distinct from *P. concolor.*

The type of *I. hirudo* has 7 teeth in the infraoral lamina, instead of 9 as in the specimens referred to *castaneus.* The origin of dorsal is said to be nearer tip of caudal than the tip of snout in *hirudo,* while in *castaneus* it is nearly midway between these two points. No second specimen properly referable to *P. hirudo* has been found, and as the characters referred to are known to be not very constant in this group, *P. hirudo* will probably be found to be identical with *P. castaneus.*

Since the above was written, we have seen an important "Note on the Chestnut Lamprey," published by Prof. F. W. Cragin, in the Bull. Washburn College Laboratory for March and April, 1885. Of four specimens of *Petromyzon castaneus* obtained by him from the mouth of Mill Creek, Shawnee Co., Kansas, one had eight mandibulary teeth, two nine, and one twelve. All had the maxillary tooth tricuspid, and the color more yellowish than in *P. concolor*. It is probable that *P. concolor* and *P. castaneus* are distinct species, distinguished chiefly by the number of supraoral cusps.

3.—PETROMYZON CONCOLOR.

Petromyzon argenteus Kirtland, Boston Journal Nat. Hist., 1840, 342, with plate (Big Miami R.). Gray, Cat. Chondr. Fish. 1851, 139 (copied). Jordan & Gilbert, Synopsis Fish. N. A., 1883, 867 (not of Bloch).

Ichthyomyzon argenteus Cope, Proc. Ac. Nat. Sci. Phila., 1864, 276 (Michigan); Nelson, Bull. Ills. Mus. Nat. Hist., I, 52, 1876. Jordan, Man. Vert., 1880, 343. Jordan & Gilbert, Synopsis Fish N. A., 10, 1882.

Ammocœtes argenteus Jordan, Man. Vert., Ed. I, 1876, 349; Jordan, Ann. N. Y. Acad. Sci., 1877, 120 (Lake Erie, White R., Ohio R).

Scolecosoma argenteum Jordan, Zool. Ohio, IV, 1882, 757.

Ammocœtes concolor Kirtland, Bost. Journ. Nat. Hist., 1840, 473, with plate (larva; Mahoning and Scioto Rivers). Gray, Cat. Chondr. Fish, Brit. Mus., 1851, 146 (copied).

Petromyzon concolor Jordan, Cat. Fish. N. A., 1885, 185.

? *Ammocœtes borealis* Agassiz, Lake Superior, 1850, 252 (Michipicoten. Lake Superior). [Description not diagnostic; may be young of *P. marinus* or of *A. branchialis*.]

? *Ammocœtes æpypterus* Abbott, Proc. Ac. Nat. Sci. Phila. 1860, 327. (Ohio River). [Description inadequate and perhaps inaccurate; may be young of *A. branchialis*.]

Petromyzon bdellium Jordan, Cat. Fish N. A., 4, 1885 (substitute for *P. argenteus*, Kirtland, preoccupied).

Habitat.—Great Lakes and Ohio and Mississippi Valleys, not rare.

The specimens examined by us are from the Ohio River at New Albany, from Ohio, from White River, Mississippi River, and from Lakes Erie and Michigan.

This species is a common parasite of the sturgeon and other large fishes.

The specific name, "*argenteus*," by which the species has been usually known, is preoccupied, for which reason Dr. Jordan has recently proposed the new name of *P. bdellium*. A study of the changes undergone by the larvæ of *P. marinus* has convinced him that the description of *Ammocœtes concolor* would apply to the larvæ of this species, the small size of the mouth being one of the characters of larval forms. This view is rendered more probable because of the presence in *concolor* of the dark dots above the gill-openings which are seen in the adult form. The *Ammocœtes borealis* of Agassiz is probably the larval form of this species, as the long description agrees almost entirely with a certain stage in the larva of *P. marinus*, and it is presumable that *P. concolor* passes through similar stages of growth. *P. concolor* is certainly known to occur in the Upper Great Lakes, whither the other species have not been traced.

The *Ammocœtes æpypterus* of Abbott, likewise based on a larval example, is not described in such a way as to enable us positively to identify it. Of the two species (*concolor, branchialis*) thus far found in the Ohio Basin, the description most resembles the former.

4.—PETROMYZON MARINUS.

Petromyzon maculosus Artedi, Ichthyol., 90, 1738 (non-binomial.) European seas.

Petromyzon marinus Linnæus, Syst. Nat., X, 1785, 230 (after Artedi, etc.).

AMERICAN SYNONYMY.

a. Anadromous form *(marinus)*.

Petromyzon marinus Günther, Cat. Fish. Brit. Mus., 1870, VIII, 501 (Nova Scotia ; Merrimack R. ; New York.). Jordan & Gilbert, Synopsis Fish. N. A., 1883, 11. Bean, Proc. U. S. Nat. Mus., 1883, 367 (Havre de Grace). Jordan Cat. Fish. N. A., 1885, 4 ; and of recent writers generally.

Petromyzon Americanus Le Sueur, Trans. Am. Phil. Soc., 1818, 373 (marine form). Storer, Rept. Fish. Mass., 1839, 195 (Charlestown). De Kay, New York Fauna, Fish. 1842, 379, pl. 66. f. 216. Gray, Cat. Chondr. Fish., 1851, 139. Storer, Synopsis, 1846, 256 ; Storer, Hist. Fish. Mass., 1867, 251, pl. 38, f. 4 (Massachusetts).

Petromyzon nigricans Le Sueur, Trans. Am. Phil. Soc., 1818, 385 (half grown). Storer, Rept. Fish. Mass., 1839, 197. De Kay, New York Fauna, Fishes, 1842, 381, pl. 79, f. 247 (copied). Linsley, "Am. Journ. Sci. Arts., 1844," (Connecticut). Storer, Synopsis, 1846, 517. Gray, Cat. Chondr. Fish., 1851, 139. Storer, Hist. Fish. Mass., 1867, 253, pl. 39, f. 6.

Ammocœtes bicolor Le Sueur, Trans. Am. Phil. Soc., 1818, 386 (larval form). Storer, Rept. Fish. Mass., 1839, 198 (copied). DeKay, New York Fauna, Fishes, 1842, 383, pl. 79, f. 248 (Connecticut R.). Gray, Cat. Chondr. Fish., 1851, 146 (name preoccupied).

Petromyzon appendix DeKay, New York Fauna, Fishes, 1842, 381, pl. 68, f. 211 (Providence ; Hudson River ; young, in fresh water). Gray, Cat. Chondr. Fish., 1851, 148.

Ammocœtes appendix Jordan & Gilbert, Synopsis Fish. N. A., 1883, 868 (copied).

? *Petromyzon lamotteni* (Le Sueur, Mss.) DeKay, N. Y. Fauna, Fishes, 1842, 382, pl. 79, f. 249 (no locality; description insufficient; possibly intended for *A. branchialis.*)
Petromyzon maculosus Gronow, Cat. Fish. Ed. Gray, 1854, 2 (Europe).

b. Land-locked form *(unicolor)*.

Ammocœtes unicolor DeKay, New York Fauna, Fishes, 1842, 383, pl. 79, f. 250 (larva; Lake Champlain). Gray, Cat. Chondr. Fish., 1851, 146.
Ammocœtes fluviatilis Jordan, Ann. N. Y. Acad. Sci., 1877. 118 (Cayuga Lake; not *Petromyzon fluviatilis* L.).
Petromyzon nigricans Jordan & Gilbert, Synopsis Fish. N. A., 1883, 11 (Cayuga Lake).
Petromyzon marinus dorsatus (Wilder, Mss.) Jordan & Gilbert, Syn Fish. N. A., 1883, 869 (Cayuga Lake). Jordan, Cat. Fish. N. A., 1885, 4.

Habitat.—Streams of North-eastern North America and of Northern Europe, south to Chesapeake Bay. Ascending rivers in the spring for the purpose of spawning, and thus land-locked in lakes and streams of Western and Northern New York.

The larva of this species is for a time blind, toothless, and with a contracted mouth, in which the lower lip forms a lobe distinct from the upper. Later this lower lobe becomes confluent with the upper, and the eyes appear, while yet the mouth is narrow and contracted. We have examined marine examples of this species, and also numerous specimens in all stages of growth from the larval to the adult form, collected by Dr. Burt G. Wilder, in Cayuga Lake, at Ithaca, N. Y. Among these are types of *P. dorsatus* Wilder, which seems to be merely a land-locked form not permanently distinct from *P. marinus.*

The name *unicolor* is based on the larva of the land-locked form, and it has priority over *dorsatus.* The characters assumed to distinguish this form from the true *marinus* are, however, more or less inconstant and not of specific value.*

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* The following are the characters assigned to *P. marinus dorsatus* (*unicolor*):

"The Cayuga Lake Lamprey is apparently a distinct subspecies, differing from *P. marinus* in the longer head (snout $1\frac{1}{3}$ in chest; head half longer than chest; in *P. marinus,* the snout is $1\frac{3}{4}$ in chest; head one-third longer than chest). Mandibulary teeth usually 8 or 9. *Males with the back before dorsal fin compressed in a long hard fleshy ridge.* Interspace between dorsals varia-

The synonymy needs little further remark. There seems to be no doubt of the identity of the American *P. americanus* with *P. marinus*. It seems also certain that *P. nigricans* is the young or river form of the same species, while *A. bicolor* represents the larval condition, blind, with the mouth contracted and toothless.

It is also most probable that *P. appendix* represents a later stage in the growth of the young lamprey; but of this we are not quite so certain.

The *P. lamotteni* of Le Sueur has the coloration of *P. marinus;* but the figure of the dentition is unsatisfactory and probably unreliable.

Additional Note on the Lamprey of Cayuga Lake.

BY SETH E. MEEK.

Since the above was in the hands of the printer, I have received from Mr. Seth E. Meek, now Fellow in Cornell University, many specimens of the Cayuga Lake Lamprey, together with the following notes, which will prove valuable for purposes of comparison. D. S. J.

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ble in length, shortest in males, $1\frac{1}{4}$ to $\frac{3}{5}$ base of first dorsal. Tail $3\frac{3}{4}$ in length. Coloration of *P. marinus*, and size not much less. Abundant in Cayuga Lake, New York; not yet observed elsewhere. The differences above noted are not very constant."

This peculiar carination of the back in breeding males has not been noticed by us in *P. marinus*. We are, however, informed by Mr. Meek, that several specimens from the streams of Massachusetts, now in the Museum of Comparative Zoology, show the same character.

MEASUREMENTS OF LAMPREYS FROM CAYUGA LAKE.

(Petromyzon marinus.)

A. Specimens with dorsal ridge well developed.

In Centimeters.										
Total length	24.90	28 70	28.80	29.	30.	30.40	31.	31.20	34.50	34.60
Length from tip of snout to vent	18.70	....	20.60	21.60	22.50	22.60	24.90	23.10	25.30	25.50
In hundredths of total length.										
Length of head	24.30	24.50	24.50	25.50	25.	24.50	24.	24.	24.	23.50
Depth of head at nostril	6.	6.50	6.50	7.	6.	6.	6.60	6.	5.90	5.90
Depth of body at origin of first dorsal (including ridge)	7.50	8.	8.20	8.50	8.10	7.50	8.30	8.	8.10	7.50
Depth of body at origin ot second dorsal (including ridge)	7.	7.20	7.60	7.90	7.50	6.90	7.	7.50	7.	7.
Transverse diameter of mouth	7.80	8.80	8.	8.20	8.30	8.20	8.30	8.10	7.80	8.
Oblique diameter of mouth	8.80	8.30	8.60	9.	8.50	8.60	8.50	8.70	8.	8.50
Diameter of eye	2.50	2.50	2.20	2.10	2.20	2.	2.	2.10	2.	2.
Distance from tip of snout to anterior margin of orbit	10.80	10.50	11.	11.50	10.20	9.50	10.50	11.	10.10	10.
Distance from tip of snout to nostril	9.10	10.10	10.	11.	9.90	9.20	9.90	9.80	9.50	9.80
Distance from tip of snout to first branchial fissure	15.	15.40	15.60	16.	15.25	15.	15.50	15.	14.50	14.20
Distance from tip of snout to anterior margin of first dorsal	51.50	51.90	50.50	51.	50.66	52.	51.50	51.50	51.50	52.20
Distance from tip of snout to anterior margin of second dorsal	66.50	66.50	62.50	66.	65.50	66.20	65.	66.50	65.	66.
Height of first dorsal (greatest)	2.60	2.50	2.50	2.30	2.90	2.80	3.	2.80	3.	3.
Height of second dorsal (greatest)	4.20	4.50	4.30	4.50	4.50	4.10	4.20	4.20	4.20	4.50
Height of dorsal ridge	1.50	1.60	1.60	1.30	1.50	1.30	1.50	1.20	1.40	1.50
Width of head at eyes	6.60	6.10	6.40	6.20	6.20	6.	6.20	6.50	6.30	6.20
Width of body at first dorsal fin	3.50	3.10	3.50	4.	3.33	3.50	3.50	4.	3.80	3.80
Length of mandibulary plate	3.	3.10	3.10	3.20	3.10	3.	3.	3.	3.10	3.
Number of mandibulary cusps	7.	8.	7.	8.	9.	8.	7.	7.	7.	7.

B. Specimens with the dorsal ridge, if present at all, not well developed.

MERSUREMENTS IN CENTIMETERS.										
Total length	25.10	26.10	26.50	27.10	27.80	30.10	31.50	31.70	33.80	35.80
Length from tip of snout to vent	18.70	19.60	19.80	20.50	21.40	22.50	23.	23.50	24.80	25.90
MEASUREMENTS IN HUNDREDTHS OF TOTAL LENGTH.										
Length of head	24 50	25.	23.50	24.	24.80	22.50	25.	21.80	22.50	31.
Depth of head at nostril	5.20	5.30	5.	5.20	5.	4.50	5.40	5.	5.10	5.
Depth of body at origin of first dorsal	8.50	6.70	8.	8.10	9.	7.50	7.60	7.50	8.	7.60
Depth of body at origin of second dorsal	7.30	6.50	7.50	7.50	8.	6.30	7.	7.30	7.	6.
Transverse diameter of mouth	7.50	7.50	7.	7,10	7.	6.20	7.			
Oblique diameter of mouth	8.	7.80	7.50	7.50	7.50	6.50	7.30			
Diameter of eye	2.	2.	2.	2.	2.10	1.90	1.90	1.90	2.	1.90
Distance from tip of snout to anterior margin of orbit	10.10	10.50	9.	10.	10.	8.20	9.20	9.50	9.80	8.90
Distance from tip of snout to nostril	9.20	9.50	8.50	9.50	9 90	7.90	8.50	9.	9.	8.
Distance from tip of snout to first branchial fissure	14.	15.	13.50	14.50	15.50	12.50	13.50	12.10	13.50	12.
Distance from tip of snout to anterior margin of first dorsal	52.	51.	53.50	53.	55.50	49.	52.	51.50	53.	51.
Distance from tip of snout to anterior margin of second dersal	67.	66.	67.80	68.	68.50	64.	66.50	66.50	68.50	67.
Height of first dorsal (greatest)	2.50	2.50	3.20	2.50	2.20	2.	2.70	2.20	1.90	1.90
Height of second dorsal (greatest)	3.80	3.90	4.50	5.	4.30	3 80	4.60	4.	3.80	2.50
Width of head at eyes	5.	5.	7.	5.50	6.	6.20	6.10	5.50	5.50	5.20
Width of body at first dorsal	4.	2.60	3.20	3.	3.80	2.50	3.90	3.50	3.50	2.50
Length of mandibulary crescent	3.	3.10	3.	3.	2.70	2.70	3.10	2.50	2.50	2.50
Number of mandibulary cusps	7.	7.	8	8.	8.	8.	8.	7.	7.	9.

Having made use of notes and suggestions from Dr. Burt G. Wilder and Prof. Simon H. Gage, I have the following to offer:

I have examined in all 106 specimens from Cayuga Lake. Of these, 64 possess the prominent dorsal ridge, on the remaining 42 the ridge is obsolete or less prominently developed.

The ridge was considered by me as a sexual distinction (present on males only), until I found gravid females with the ridge quite prominent.

The papilla at vent also proved to be rather an unsafe guide, and so I resorted to an examination of the ovaries or testes. This was equally unsatisfactory. A few very doubtful cases were referred to Prof. Gage for microscopical examination, which resulted in more doubt than ever. He did not think that he could tell with absolute certainty which were males or which were females, without some previous study of fresh specimens. All that is left is to get these and study them from a sexual standpoint, which thing we intend to do as soon as possible.

It seems to me that the question has this value in classification: if we find that the dorsal ridge is peculiar to the lampreys* of Cayuga Lake, that all males possess it, and no males are found without it, it is a character of specific rank. If on the other hand, males are found without the dorsal ridge as well as with it, and the same prove true of females, the character is without value in classification.

It may be the case that the ridge is to the lampreys as "horns" are to some minnows, but I hardly think so.

There are no whole specimens from the Atlantic in the Cornell University Museum. A few are here in sections, having been used for class study. The dentition of these is the same as that of the Cayuga Lake specimens.

The mandibulary cusps are as follows:

Sea lampreys (Heads),	2	with	7	cusps.
	6	"	8	"
	—			
	8			

* Since the above was written, Mr. Meek has shown that the dorsal ridge is present in many specimens of *P. marinus* (from Lawrence, Mass.), and that no distinction exists between the latter and the Cayuga Lamprey, except that the latter does not reach the fult size of the former.

Lake lampreys (heads),	3	with	7	cusps.
	3	"	8	"
	4	"	9	"
	10			

Cayuga Lake Specimens.	No. with 7 cusps.	No. with 8 cusps.	No. with 9 cusps.
Specimens with well developed ridge,	26	23	15
Specimens without well developed ridge,	11	21	10
Total, - - - - - -	37	44	25
Grand total, - - -		106	

When there are more than seven cusps, usually from two to four or five are smaller than the others. I noticed no variation in the disposition of the other teeth.

The mandibulary plate is proportionally about the same length in all specimens; its cusps are from 7 to 9.

The caudal margin of the cephalic dorsal fin is always distinct. In a few specimens the dorsal fins are well separated, the distance between them in some cases equals the distance from first to fifth branchial fissure. This separation is greater and occurs oftener in specimens without the dorsal ridge.

The height of dorsal fins varies in different individuals. The fins are usually lower when the distance between them is greater.

The caudal margin of the caudal dorsal is in all specimens quite distinct, the distance from its caudal margin to tip of caudal varies in different individuals; it is longer in the more slender specimens. The distance from caudal margin of caudal dorsal to tip of caudal fin is in some individuals nearly equal to distance from caudal border of eye to seventh branchial fissure.

A transection at nostril would cut or pass slightly cephalad of cephalic margin of orbit.

The distance from first to fifth branchial fissure is in some specimens slightly greater than the distance from nostril to tip of snout; in some specimens equal to this distance, in others much less. These characters vary as stated in all mature specimens, whether large or small. Among the many larval specimens examined, those of the same size all look alike.

Genus 3.—AMMOCŒTES.

LAMPREDA Rafinesque, Analyse de la Nature, 1815, 94 (name only).
PRICUS Rafinesque, l. c. (name only).
AMMOCŒTES (Duméril), Cuvier, Regne Animal, Ed. I, 119, 1817 (*branchialis*, a larval form).
LAMPETRA Gray, Proc. Zool. Soc. London, 1851, 235 (*fluviatilis*).
CHILOPTERUS Philippi, Wiegmann's Archiv, 1858, 306 (larva).
ENTOSPHENUS Gill, Proc. Ac. Nat. Sci. Phila., 331, 1862 (*tridentatus: nomen nudum*).
ENTOSPHENUS Jordan & Gilbert, Synopsis Fishes N. A., 1883, 7 : 867 (*tridentatus*).

This genus will perhaps admit of further subdivision, as Dr. Gill has suggested, but to us, the characters distinguishing *Ammocœtes* and *Entosphenus* seem rather of subgeneric value.

ANALYSIS OF SPECIES OF AMMOCŒTES.

a. Supraoral lamina with a well-developed median cusp which is about half the length of the other two ; anterior lingual tooth wedge-shaped with an almost straight, finely serrate edge ; dorsal fin divided ; buccal disk moderate. Marine species of large size, anadromous (*Entosphenus* Gill).

b. Infraoral lamina with five or six cusps ; teeth on buccal disk mostly in one series ; those above mouth unicuspid, those on sides of disk larger, the first and last bicuspid, the two middle ones tricuspid ; those below rather small, mostly bicuspid ; space between dorsals about two-fifths length of first dorsal ; head about 10 in length ; 73 muscular impressions between last gill-opening and vent ; color plain dark brown. - - - - - - - TRIDENTATUS, 5.

aa. Supraoral lamina with a very small median cusp or with none ; anterior lingual tooth little developed, with a crescentiform dentated edge, the median denticle enlarged ; buccal disk small, with the teeth few and small, none of them tricuspid ; small species, mostly *fluviatile* (*Ammocœtes*).

c. Dorsal fin divided into two fins, which are separate, or joined at base only.

d. Infraoral lamina with 7 cusps, the outer ones largest ; head shorter than thorax, $10\frac{1}{3}$ in total length ; interspace between dorsals $1\frac{1}{2}$ in in first dorsal ; height of first dorsal half that of second ; color plumbeous above, golden below. - - - - AUREUS, 6.

dd. Infraoral lamina with 8 or 9 subequal cusps ; about three bicuspid teeth on each side of buccal disk ; teeth on upper part of disk simple ; head 10 in length ; dorsal fins slightly connected by membrane at base ; second dorsal not much higher than first, much lower than in *A. branchialis* ; insertion of dorsal a little behind middle of body: 63 muscular depressions between last gill-opening and vent ; color plumbeous above, sides and below silvery. - - CIBARIUS, 7.

cc. Dorsal fin continuous, the two parts of the fin separated not quite to base by a sharp notch ; insertion of dorsal fin a little before middle of body ; both dorsals high, the first $1\frac{3}{4}$ in height of second ; teeth very feeble ; infraoral plate with from 5 to 9 feeble, bluntish, subequal cusps, about 3 bicuspid teeth on each side of buccal disk ; teeth on upper part of disk simple ; supraoral lamina rarely with a median cusp ; head about as long as thorax, $8\frac{1}{2}$ in total length ; 67 muscular impressions between last gill-opening and vent ; color bluish-black, silvery below. - - - - - BRANCHIALIS, 8.

5.—AMMOCŒTES TRIDENTATUS.

?*Petromyzon marinus camtschaticus* Pallas, Zoogr. Rosso-Asiatica, III, 1811, 67 (Kamtschatka).

Petromyzon tridentatus Gairdner Mss., Richardson, Fauna Boreali-Americana, 1836, 293 (Columbia River). DeKay, New York Fauna, Fishes, 1842, 382 (copied). Storer, Synopsis Fish. N. A., 1846, 266 (copied). Gray, "Proc. Zool. Soc., London, 1851, 240, pl. 19." Gray, Cat. Chondr. Fish. Brit. Mus., 1851, 144. Girard, U. S. Pac. R. R. Surv., 377, 1858 (Fort Reading, Cal.).

Entosphenus tridentatus Gill, Proc. Ac. Nat. Sci. Phila., 1862, 331 (name only). Jordan & Gilbert, Proc. U. S. Nat. Mus., 1880, 458, and 1881, 30 (Columbia R. at Astoria and Monterey Bay at Santa Cruz). Jordan & Gilbert, Syn. Fish. N. A., 1883, 868.

Ichthyomyzon tridentatus Günther, Cat. Fish. Brit. Mus., VIII, 1870, 506 (copied).

Lampetra tridentata Jordan & Gilbert, Synopsis Fish. N. A., 1883, 7. Bean, Proc. U. S. Nat. Mus., 1882, 89, 93 (Walla Walla River, and Garrison Creek Washington Ter.).

Ammocœtes tridentatus Jordan, Cat. Fish. N. A., 1885, 3.

Petromyzon ciliatus Ayres. Proc. Cal. Ac. Sci. 1855, 43 (San Francisco). Girard, U. S. Pac. R. R. Surv., 1858, 378 (San Francisco).

Entosphenus ciliatus Gill, Proc. Ac. Nat. Sci. Phila., 1862, 331 (name only).

Petromyzon lividus Girard, U. S. Pac. R. R. Surv., 1858, 378 (Wahmahmath R.).

Petromyzon astori Girard, U. S. Pac. R. R. Surv., 1858, 380 (Columbia R. at Astoria).

Entosphenus astori Gill, Proc. Ac. Nat. Sci. Phila., 1862, 331 (name only).

Ichthyomyzon astori Günther, Cat. Fish., VIII, 1870, 307 (copied).

Lampetra astori Jordan & Gilbert, Syn. Fish. N. A., 1883, 8 (copied).

Entosphenus epihexodon Gill, Proc. Ac. Nat. Sci. Phila., 1862, 331 (based on *Petromyzon tridentatus* Girard, erroneously supposed to be distinct from *P. tridentatus* Gairdner).

Lampetra epihexodon Jordan & Gilbert, Syn. Fish. N. A., 1882, 8 (copied).

Habitat.—Coasts of Western North America, from British Columbia to Monterey, ascending rivers in spring to spawn.

The studies and collections of Professors Jordan and Gilbert on the Pacific Coast of North America, seem to leave no doubt that all the specimens of anadromous lampreys on the Pacific Coast (called *tridentatus, ciliatus, lividus, astori* and *epihexodon* by authors) are forms of a single species.

The specimen now before us is from Walla Walla, and is 26 inches in length. It was obtained by Capt. Charles Bendire.

6.—AMMOCŒTES AUREUS.

??*Petromyzon fluvialis* Richardson, "Franklin's First Journey, 1823, 705" (Arctic America). ? Richardson, Fauna Boreali-Americana, 1836, 284 (not *P. fluviatilis* L.).

??*Petromyzon borealis* Girard, U. S. Pac. R. R. Surv., 1858, 377 (no description; based on Richardson; not *Ammocœtes borealis* Agassiz).

Ammocœtes aureus Bean, Proc. U. S. Nat. Mus., 1881, 159 (Anvik, Yukon R.). Jordan & Gilbert, Synopsis Fish. N. A., 1882, 868 (copied). Jordan, Cat. Fish. N. A,, 1885, 4.

Habitat.—Streams of Alaska.

This species is known to us only from the description of Dr. Bean. It seems to approach more nearly than any other of our species to the European *Ammocœtes fluviatilis* L. A comparison of Dr. Bean's description with figures of the latter species shows numerous differences in details of measurement.

7.—AMMOCŒTES CIBARIUS.

Petromyzon plumbeus Ayres, Proc. Cal. Ac. Nat. Sci., 1855, 27 (San Francisco). Girard, U. S. Pac. R. R. Surv., 1858, 380 (San Francisco). (Not *Petromyzon plumbeus* Shaw.)

Lampetra plumbea Gill, Proc. Ac. Nat. Sci. Phila., 1862. 331 (name only). Jordan & Gilbert, Syn. Fish. N. A., 1883, 8 (copied).

Ammocœtes plumbea Jordan & Gilbert, Proc. U. S. Nat. Mus., 1880, 458; 1881, 30 (Seattle, Puget Sound; San Francisco). Bean, Proc. U. S. Nat. Mus., 1882, 93 (Garrison Creek, near Walla Walla).

Ammocœtes cibarius Girard, U. S. Pac. R. R. Surv.. 1858, 383 (Puget Sound, larval form). Jordan, Cat. Fishes N. A., 1885, 4.

Petromyzon ayresi Günther, Cat. Fish. Brit. Mus., VIII, 505, 1870 (British Columbia).

Habitat.—Rivers of Western North America from Frazer's River to the Sacramento.

This small species seems to be chiefly confined to the fresh waters along the Pacific Coast. The specimens before us are about 7 inches in length, and come from near Walla Walla, where they were collected by Capt. Charles Bendire.

There seems to be no doubt that the *Ammocœtes cibarius* of Girard is simply the larva of this species. The older name, *plumbeus*, cannot be retained, as the name *Petromyzon plumbeus* was long ago given by Shaw to another species.

8.—AMMOCŒTES BRANCHIALIS.

European Synonymy.

Petromyzon pinna dorsali posteriori lineari, etc. Linnæus, Fauna Suecica, 274 (larva).
Petromyzon branchialis Linnæus, Syst. Naturæ, X, 1758, 230 (based on the Fauna Suecica,) and of late authors.
Ammocœtes branchialis Cuvier, Règne Animal, 1827, and of many authors.
Petromyzon planeri Bloch, Fische Deutschlands, III, 47, about 1785, and of many authors.
*Le Petromyzon rouge** Lacépède, Hist. Nat. Poiss., II, 99, f. 1, 1798 (Rouen; larva).
*Le Petromyzon sucet** Lacépède, op. cit., II, 101, 1798 (Rouen).
Petromyzon septœuil Lacépède, op. cit., IV, 667, 1803 (Rouen).
Petromyzon niger Lacépède, op. cit., IV, 667, (Louviers).
Petromyzon bicolor Shaw, Gen'l Zool., V, 2, 263, 1805.
Petromyzon plumbeus Shaw, l. c.
Petromyzon lumbricalis Pallas, Zoogr. Rosso-Asiat., III, 69, 1811 (larva).
Petromyzon cœcus Couch, "Lond. Mag. Nat. Hist., V, 23, f. 10" (larva).

American Synonymy.

Petromyzon nigrum Rafinesque, Ichth. Ohiensis, 1820, 84 (near Falls of Ohio).
Petromyzon niger Jordan, Man. Vert., Ed. I, 1876, 315. Nelson, Bull. Ills. Mus. Nat. Hist., I, 1876, 52. (Not of Lacépède.)
Ammocœtes niger Jordan, Ann. N. Y. Acad. Sci., 1877, 120 (Fox R., Peckatonica R., White R., Rock R., Wabash R.). Jordan, Bull. Ills. Lab. Nat. Hist., 1878, 70. Jordan, Man. Vert., Ed. 2, 1878, 349. Jordan, Zool. Ohio, 1882, 756. Jordan & Gilbert, Syn. Fishes N. A., 1882, 9.
Ammocœtes æpypterus Jordan, Cat. Fishes N. A., 1885, 4 (not of Abbott).

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* To these species, only French names were given by Lacépède. The Latin names, *P. ruber*, and *P. sanguisuga*, were supplied by later writers.

Habitat.—Streams of Wisconsin and Indiana. Probably throughout the Mississippi Valley.

This little species is very abundant in the spring in many streams of Southern and Central Indiana and in Southern Wisconsin. Its distribution outside of these regions is unknown; but it will probably be found in all parts of the Upper Mississippi Valley. Part of the numerous specimens before us are from Big Prairie Creek, a tributary of the Peckatonica River near Monroe, Wis., collected by Mr. Winfred Copeland. Other specimens are from the streams about Bloomington, Indiana. All are about eight inches in length.

This species ascends the streams in spring, and is then found in the little brooks and spring runs in some abundance. Later, it disappears. We have never seen its larva, nor any specimens taken in summer or fall.

This is unquestionably the *Petromyzon nigrum*, carelessly described by Rafinesque.

It may be that it is Le Sueur's *P. lamotteni*, known only from a drawing of Le Sueur, published after his death. But this drawing is either unfinished or inaccurate; and while the dentition figured looks somewhat like that of the present species, the coloration is that of *P. marinus*. We think that *P. lamotteni* must be regarded as unidentifiable. The possibility of the identity of *Ammocœtes borealis* and *Ammocœtes æpyptera* with the larva of this species, has been elsewhere discussed.

We have carefully compared our specimens with descriptions and figures of the European species, especially with those given in Day's Fishes of Great Britain and Ireland. We can detect no differences whatever, and are therefore compelled to record our specimens under the name of *Ammocœtes branchialis*. Should comparison of specimens show that real differences exist, a new name must be given to the American species, as the name *niger* has been already used in this genus.

List of Nominal Species of Petromyzontidæ mentioned in the present paper.

(Tenable specific names are in *italics*.)

Nominal Species.	*Date.*	*Identification.*
Petromyzon *marinus* L. - - - -	1758	P. marinus.
" *branchialis* L. - - - -	1758	A. branchialis.
" planeri Bloch, - - -	1785?	A. branchialis.
" (ruber) Lacépède, - - -	1798	A. branchialis.
" (sanguisuga) Lacépède, -	1798	A. branchialis.
" septoeuil Lacépède, - -	1803	A. branchialis.
" niger Lacépède, - - -	1803	A. branchialis.
" bicolor Shaw, - -	1805	A. branchialis.
" plumbeus Shaw, - -	1805	A. branchialis.
" lumbricalis Pallas, - - -	1811	A. branchialis.
" (marinus) camtschaticus Pallas,	1811	A. tridentatus ?
" cœcus Couch, - - -	1813	A. branchialis.
" americanus Le Sueur, -	1818	P. marinus.
" nigricans Le Sueur, - -	1818	P. marinus.
Ammocœtes bicolor Le Sueur, - -	1818	P. marinus (larva).
Petromyzon nigrum Rafinesque, - -	1820	A. branchialis.
" *tridentatus* Gairdner, - -	1836	A. tridentatus.
" argenteus Kirtland, - -	1840	P. concolor.
Ammocœtes *concolor* Kirtland, - -	1840	P. concolor (larva).
Petromyzon appendix DeKay, - - -	1842	P. marinus
Ammocœtes unicolor DeKay, - -	1842	P. marinus (larva).
Petromyzon lamotteni Le Sueur, - -	1842	? P. marinus.
Ammocœtes borealis Agassiz. - -	1850	? P. concolor (larva).
Petromyzon maculosus Gronow, -	1854	P. marinus.
" ciliatus Ayres, - - -	1855	A. tridentatus.
" plumbeus Ayres, - - -	1855	A. cibarius.
" lividus Girard, - - -	1858	A. tridentatus.
" astori Girard, - - -	1858	A. tridentatus.
" borealis Girard, - - -	1858	A. —— ?
Ammocœtes *cibarius* Girard, - - -	1858	A. cibarius.
Ichthyomyzon *castaneus* Girard, - -	1858	P. castaneus.
" hirudo Girard, - - -	1858	P. castaneus (?hirudo).
Ammocœtes *æpyptera* Abbott, - -	1860	? P. concolor (larva).
Entosphenus epihexodon Gill, - - -	1862	A. tridentatus.
Petromyzon ayresi Günther, - - -	1870	A. cibarius.
Ammocœtes *aureus* Bean, - - - -	1881	A. aureus.
Petromyzon marinus dorsatus Wilder, -	1883	P. marinus.
" *bairdi* Gill, - - - - -	1883	Bathymyzon bairdi.
" bdellium Jordan, - -	1885	P. concolor.

RECAPITULATION.

Genus 1.—Bathymyzon Gill.

(Doubtful genus ; possibly based on a mutilated *Petromyzon ?*)

1. Bathymyzon bairdi Gill. (Species not well known.)

Genus 2.—Petromyzon (Artedi) Linnæus.

§ *Ichthyomyzon* Girard.

2. Petromyzon castaneus Girard. (Possibly two species : *hirudo, castaneus,* contained in the synonymy.)
3. Petromyzon concolor Kirtland.

§ *Petromyzon.*

4. Petromyzon marinus L.

Genus 3.—Ammocœtes Duméril.

§ *Entosphenus* Gill.

5. Ammocœtes tridentatus Gairdner.

§ *Ammocœtes.*

6. Ammocœtes aureus Bean.
7. Ammocœtes cibarius Girard.
8. Ammocœtes branchialis Linnæus. (Possibly distinct from the European species, in which case a new name should be given to the American form.)

Indiana University, October 21, 1885.

XVI.—*A Review of the Genera and Species of Diodontidæ found in American seas.*

BY CARL H. EIGENMANN.

Read December 21, 1885.

At the suggestion of Dr. David S. Jordan, I have made a study of the American *Diodontidæ*, with a view to ascertain the number of valid species and their correct nomenclature. I give in this paper the synonymy of the species recognized, with keys for their identification. The specimens studied belong to the Museum of the Indiana University, at Bloomington, Ind. Some important questions in regard to the species cannot be settled without a greater amount of material than has been at my disposal; but it is believed that the conclusions here reached represent some advances in our knowledge. I am indebted to Miss Rosa Smith for the description of two specimens from La Paz, at San Diego.

The American genera are two, which may be defined as follows:

a. Body moderately inflatable; head broad: nasal tentacle in front of eye, with two lateral openings; jaws without median sutures; vertical fins rounded; pectorals short, broad.

b. Spines slender, mostly two-rooted, erectile; in the three-rooted spines, the anterior root is formed by a prolongation of the anterior ridge of the spine.

DIODON, 1.

bb. Spines robust, all three-rooted, fixed; the anterior root similar to the lateral roots.

CHILOMYCTERUS, 2.

1. DIODON.

DIODON Linnæus, Syst. Nat., Ed. X, 335, 1758 (*atinga, hystrix*, etc.).
? TRICHODIODON Bleeker, "Atl. Ichth. Gymnod., 49," 1865 (*pilosus*).
PARADIODON Bleeker, "Atl. Ichth. Gymnod., 56, plate 3, fig, 2," 1865 (*hystrix*).

The genus *Trichodiodon* is based on a description by Mitchill, of a species which has not been since recognized. It is not unlikely that it is simply the very young of *Diodon hystrix*. At any rate, its place in the system needs verification.

The name *Paradiodon* is the result of Bleeker's rule of always regarding the first species mentioned in any new genus as the type of the genus. In this case, *atinga* is the first species mentioned under *Diodon* by Linnæus, and this *atinga* is a species of *Chilomycterus*.

ANALYSIS OF THE SPECIES OF DIODON.

a. Spines terete. - - - - - - - - - HYSTRIX, 1.

b. Frontal spines not as long as post-pectoral spines (in adults not half as long, about as long as eye); pre-dorsal spines very short, three-rooted, fixed or nearly so; 20 spines in a series between snout and dorsal; post-pectoral spines very much elongate; dorsal rays, 15; anal, 15; upper lobe of pectorals little longer than lower. Adult above everywhere spotted with round black spots; these are largest in front of dorsal, smallest on naked area about mouth; white below; young with large dark blotches, the coloration precisely similar to that of *holacanthus*. - - - - Var. HYSTRIX.

bb. Frontal spines longer than post-pectoral spines, about twice as long as eye; pre-dorsal spines not shortened, two-rooted, erectile; 14 to 17 spines in a series between snout and dorsal; post-pectoral spines not especially elongate; dorsal rays, 12; anal, 12; pectoral broader than long, upper lobe pointed, lower lobe rounded. A broad black bar from eye to eye, continued below the eye as a narrow bar; a broad bar across occiput; a black blotch above each pectoral; a short bar in front of dorsal; another in which the dorsal is inserted; a blotch behind the pectoral, and many small spots and blotches on the upper parts. - - - - - - Var. HOLACANTHUS.

aa. "Spines compressed laterally, short; 15 spines in a series between snout and dorsal; upper parts covered with round spots; those about pectorals sometimes confluent into a blotch; fins immaculate." MACULIFER, 2

1. DIODON HYSTRIX

a (var. *hystrix.*)

Orbis echinatus Rondelet, De Piscibus, 324, 1558 ("Northern Ocean").

Guamajacu guara Marcgrave, Hist. Nat. Bras., 159, 1648 (Brazil).

Porc-epics de Mer Froger, Voyage de la Mer du Sud, 119, 1715 (Isles Sainte Anne).

Ostracion conico oblongus Artedi, Genera, 60, No. 19. Sueci Desc. Spec. Pisc., 86, No. 21, 1738.

Crayracion Nos. 12, 13, 14, Klein, Historia Pisc., 19 and 20, 1740.

Erizo Parra, Desc. Dif. Piezas Hist. Nat. Cuba, 60, tab. 29, fig. 1, 1787 (Havana).

Diodon hystrix Linnæus, Syst. Nat., Ed. X, 335, 1758 (India: after Artedi). Id., Ed. XII, 413, 1766 (Cape Good Hope). Bloch, Auslandische Fische, I, 91, plate cxxvi, 1787. Gmelin, Syst. Nat, 1448, 1788 (copied). Walbaum, Artedi Pisc., 597, 1792 (copied). Bloch & Schneider, Syst. Ichth., 512, 1801 (Indian Ocean; copied). Turton Ed. Linnæus Syst. Nat., I, 892, 1806 (Indian and American Seas). Cuvier, Règne Animal, Ed. II, 336 (note), 1829. Oken, Naturgeschichte, VI, 116, 1836. Barneville, "Revue Zoöl., 141," 1846. Bleeker, En. Spec. Pisc. Arch. Ind., 203, 1859 (Java, Sumatra, Batu, Celebes, Flores, Ternate, Amboina, Ceram, Banda, *in mari*). Castelnau, Mem. Poiss. l'Afr. Aust., 74, 1861. Günther, Voy. Challenger, 58, 1869 (Tahiti). Id., Cat. Fish Brit. Mus., VIII, 306, 1870 (West Indies, Jamaica, Indian Ocean). Klunzinger, Syn. Fisch. Rothen Meeres, 647, 1870 (Red Sea). Cope, Trans. Am. Phil. Soc., 480, 1870 (Lesser Antilles). Goode, Proc. U. S. Nat. Mus., 1879, 109 (East Coast Florida). Bean, Proc. U. S. Nat. Mus., 1880, 75 (Bermudas). Swain & Smith, Proc. U. S. Nat. Mus., 1882, 141 (Johnston's Island, Mid-Pacific). Jordan & Gilbert, Bull. U. S Fish Com., 1882, 105 (Mazatlan). Jordan & Gilbert, Syn. Fish N. A., 863, 1883. Jordan, Proc. U. S. Nat. Mus., 1884, 146 (Key West). Id., Cat. Fish N. A., 141, 1885 (name only). Id., Proc. U. S. Nat. Mus., 1885, 393 (Mazatlan).

Holocanthus hystrix Gronow, Cat. Fish. Ed. Gray, 27, 1854 (American Seas.)

Paradiodon hystrix Bleeker, "Atl. Ichth. Gymnod, 56, plate 3, fig. 2," 1865. Poey, Syn. Pisc. Cub., 430, 1868. Id., Enum. Pisc. Cub., 169, 1875. Goode, Bull. U. S. Nat. Mus., V, 21, 1876 (Bermudas). Bleeker, L'île Maurice, 23, 1878. Poey, Anal. de Hist. Nat., 346 (Porto Rico).

Diodon atinga var. *hystrix* Walbaum, Artedi, Pisc., 596, 1792.

Diodon atinga Bloch, "Ichth., IV, 75," plate cxxv, 1787. Gmelin, Syst. Nat., 1451, 1788 (in part). Walbaum, Artedi, Pisc., 597, 1792 (copied). Bloch & Schneider, 511, 1801 (copied). Shaw, Gen. Zool., V, 434, 1804. Müller & Troschel, "Hist. Barbadoes, 677," 1848. Ruppell, "Verz. Senckenb. Mus. Fish. 35," 1852. Kaup, "Wiegm. Arch., XXI, 227," 1855. Bleeker, Enum. Pisc. Arch. Ind., 203, 1859 (Java, Sumatra, Batu, Celebes, Flores, Ternate, Amboina, Ceram). Castelnau, Mem. Poiss. l'Afr. Aust., 74, 1861. Juan. Anim. Nov. Caledonie, Mem. Soc. Imp. Sci. Nat. Cherbourg, 18, 1861–63.? Cope, Trans. Amer. Phil. Soc., 480. 1870 (St. Martins, New Providence ; Tortugas). [Not *Diodon atinga* L., which is a species of *Chilomycterus*]

Le Diodon atinga Lacépède, Poissons, II, 1–10, plate XXV, fig. 3, 1798.

Le Diodon plumier Lacépède, Poissons, II. 1 and 10, plate III, fig. 3, 1798 (Martinique ; on a drawing by Plumier).

Le Diodon holocanthe Lacépède, Poissons, II, 1798 (copied).

Diodon brachiatus Bloch & Schneider, 513. 1801 (after Parra, tab. 29, fig. 1).

Diodon punctatus Cuvier, Mem. Mus. Hist. Nat., IV, 132, 1818. Id., Règne Animal, Ed. II, 336 (note), 1829. Bleeker, "Verh. Bat. Gen., XXIV, Blootk. Visch., 19," 1852. Bleeker, Achtste Bij. Ichth. Fauna Celebes, 301, 1855 (Macassar). Id., Zesde Bij. Ichth. Fauna, Amboina, 403, 1855. Id., Consp. "Molucc. Coquit., 21" (Amboina, Ternate, Ceram, Archip. Molucc., Banda). Id., "Elfde Bij. Visch. Celebes, 4" (name only). Id., Zez. Bij. Visch. Sumatra (Lampony). Id., Reschrij. Visch. Amboina, 8, 23 (name only). Id., "Bij. Visch. Amboina, 28" (name only) Id., Tweede Bij. Ichth. Fauna Batoë, 4 (name only, Batoë).

Diodon echinus "Rafinesque." Bonaparte. Cat. Met. Pisc. Eur., 87, 1846 (Mediterranean Sea, accidental).

Diodon pilosus DeKay, Nat. Hist. New York, 326, plate LV, fig. 180, 1842 (New York). [Young ; perhaps not *Diodon pilosus* Mitchill.]

Diodon maculatus var. β, Günther, Cat. Fish. Brit. Mus., VIII. 307, 1870 (East Indian Arch., Amboina .

Habitat.—All warm seas.

(*b.* var. ? Holacanthus.)

Crayracion, Nos. 9 and 15, Klein, Historia Pisc., 19 and 20 tab. 3, fig. 6, 1740.

Ostracion oblongus holacanthus Artedi, Genera 60, No. 20 ; Sueci. Desc. Spec. Pisc., 86, No. 22, 1738.

Diodon holacanthus Linnæus, Syst. Nat., Ed. X, 335.1758 (India ; based on Artedi). Gmelin, Linnæus, 1451, 1788 (American Seas and Good Hope).

Diodon atinga var. *holacanthus* Walbaum, Artedi Pisc., 598, 1792 (copied).

Diodon hystrix, var. β, Linnæus, Syst. Nat., Ed, XII, 413,1766 (Cape Good Hope).

?*Diodon pilosus* Mitchill, Fish. New York, 471. plate VI, fig. 4, 1814 (New York). Cuvier, Règne Animal. 337 (note), 1829 (very young).

?*Trichodiodon pilosus* Günther, Cat. Fish. Brit. Mus., VIII, 316, 1870 (copied). Jordan & Gilbert, Syn. Fish. N. Am., 862, 1883 (copied). Jordan, Cat. Fish. N. Am., 141, 1885 (name only).

Diodon spinosissimus Cuvier, Mem. Mus., IV, 134, 1818. Id., Règne Animal. 336 (note). 1829. Günther, Cat. Fish. Brit. Mus., VIII, 307, 1870 (Cape Good Hope ; Siam ; and type of *D. melanopsis* Kaup.).

Diodon melanopsis Kaup., Wiegm. Arch., 1855, 228.

Paradiodon quadrimaculatus Bleeker, "Atl. Ichth., Gymnod., plate 8, fig. 2," 1865.

Diodon maculatus var. *a*, Günther, Cat. Fish. Brit. Mus., VIII, 307, 1870 (St. Croix ; Jamaica ; Panama ; South America ; Sandwich Is. ; China ; Sooloo Sea ; Indian Ocean).

Diodon maculatus Jordan & Gilbert, Proc. U. S. Nat. Mus., 1880, 453 (La Paz), and 1881, 70 (La Paz).

Diodon liturosus Jordan, Proc. Acad. Nat. Sci. Phil., 1884, 46 (*Diodon maculatus* var. *a* Günther).

Habitat. All warm seas, its range apparently co-extensive with that of *D. hystrix.*

The following references belong apparently chiefly, to *Diodon holacanthus*, but in some cases the young of *D. hystrix* is more or less confused with the former.

Erizo Guanabana Parra. Desc. Dif. Piezas Hist. Nat. Cuba, 62, tab. 29, fig. 2, 1787 (Havana).

Le Diodon tacheté Lacépède, Poissons. II, 13, 1798 (New Cytherea).

Diodon atinga Turton, Ed. Linnæus Syst. Nat., 893, 1806 (compiled).

Diodon liturosus Shaw, "Gen. Zool., V, pl. 2, 436," 1804 (after *Diodon tacheté* Lacépède). Jordan & Gilbert. Proc. U. S. Nat. Mus., 1882, 377 (Panama). Bean, Collection Fish. Internat. Fish. Exh. London, 42, 1883 (Garden Key . Jordan, Proc. U. S. Nat. Mus., 1884, 150 (Florida Keys). Bean & Dresel, Proc. U. S. Nat. Mus., 1884, 151 (name only). Jordan, Cat. Fish. N. Am., 141, 1885 (name only). Id., Proc. U. S. Nat. Mus., 1885, 393 (Lower California).

Diodon novemmaculatus Cuvier, Mem. Mus. Hist. Nat., IV, 136, plate 6, 1818. Id., Règne Animal. Ed. II, 336 (note), 1829. Brevoort, Fish Japan, 285, 1850. Bleeker, Nat. Tyds. Ned. Ind., III, 567, 1852. Id., Con. Spec. Mol. Huc. Cogn., 21 (Amboina). Id., Zesde Bij. Ichth. Fauna (Amboina), 403, 1855.

Paradiodon novemmaculatus Bleeker, "Atl. Ichth., V, 57, plate 206," 1865. Id., Poissons du Japan, 26, 1879.

Diodon sexmaculatus Cuvier, Mem. Mus. Hist. Nat., IV, 136, plate 7, 1818. Id., Règne Animal, 336 (note). Kaup, "Arch. Naturgesch., XXI, I, 229," 1855. Bleeker, Enum. Pisc. Arch. Ind., 203. 1859 (Japan; Sandwich Is.; Hindostan ; Mauritius ; Good Hope). Günther, Fish. Central Am., 396, 1869 (Panama).

Diodon quadrimaculatus Cuvier, Mem. Mus. Hist. Nat., IV, 137, plate 6, 1818 (Otaiti). Bleeker, Enum. Pisc. Arch. Ind., 203, 1859 (Amboina). Id., "Act. Soc. Sci. Indo. Neerl., II, Amboina, VIII, 94."
Diodon multimaculatus Cuvier, Mem. Mus. Hist. Nat., IV, 136, 1818. Id., Règne Animal, 336 (note), 1829. Kaup, "Arch. Naturgesch., XXI, I, 227," 1855.
Paradiodon sp. dubia Poey, Syn. Pisc. Cub., 431, 1868 ("Compárese con el *D. pilosus* de Mitchill").
Diodon maculatus var. γ & δ, Günther, Cat. Fish. Brit. Mus., VIII, 308 (Amboina; West Indies; Cape Good Hope; Bourbon; Formosa).
Diodon maculatus Streets, Bull. U. S. Nat. Mus, VII, 43 (Lower Cal.).

In the foregoing synonymy, several references are of course doubtful, on account of the confusion in authors of the young of *D. hystrix* with the adult of the variety *holacanthus*.

The *Diodon atinga* of Linnæus is certainly a *Chilomycterus*, probably *Ch. jaculifer* of Günther, but the species so called by Bloch and those following him is the *hystrix* of Linnæus.

Diodon brachiatus of Bloch & Schneider is based upon Parra, tab. 29, fig. 1; this plate represents *D. hystrix*.

The figure of *Diodon pilosus*, given by DeKay, is apparently a young *hystrix;* the *pilosus* of Mitchill is perhaps the young of *holocanthus*, or possibly of some species still unrecognized, with very slender spines.

Under the head of *Diodon maculatus*, Dr. Günther includes the true *holacanthus* and also the young of *hystrix*. The markings of the body are the same in both, and in one young specimen examined (141) the small round spots characteristic of the adult of *hystrix* were seen within the round black blotches which had faded somewhat.

The specimens before me are from Havana, Saint Thomas and Lower California.

As shown by the evidence at my disposal, the form or variety or species, *Diodon holacanthus* differs from *D. hystrix* in having the frontal spines as long as the post-pectoral spines, and in having all of its spines long and similar in form; all without any anterior root.

The *holacanthus* of Linnæus is based upon a description of Artedi. As this description fits this form rather than the *hystrix*, I have substituted the name *holacanthus* for the *liturosus* of Shaw and the *maculatus* of Günther. Shaw based his name *liturosus* on Lacépède's description of his "Le diodon tacheté." Lacépède describes merely the coloring of this specimen, giving general statements about the spines; this leaves it uncertain which species he had. All the references of authors to *liturosus* are equally doubtful, except in the few cases where the specimens have been especially described. The *spinosissimus* of Cuvier is a *holacanthus*, and the fact that Günther refers his specimens to the *holacanthus* seems to indicate that they belong there, although he does not mention in his description the prolongation of the frontal spines. The descriptions of *novemmaculatus*, *sexmaculatus*, *quadrimaculatus* and *multimaculatus*, are none of them so exact as to leave no doubt as to the species intended; although in all these cases I think it likely that *holacanthus* is meant rather than the young of *hystrix*. *Diodon maculatus* var. *α* Günther is certainly a *holacanthus*; var. *β* is a *hystrix*. The others I can not certainly identify.

The specimens examined by me are from Havana.

If, as is possible, this is only a variation of the young of *hystrix*, all the foregoing synonymy should be referred to the latter. At present I think the probabilities are in favor of absolute identity of the two forms, but pending the settlement of this question, it has seemed best to group the synonymy as above.

I give below a tabulated account of the different specimens examined by me, and those described by various writers, which seem referable to *Diodon hystrix* and *D. holacanthus*. The extent of the variations in the diagnostic characters will appear from this account.

A. Armature of the tail.

b. In specimens described by authors, and referred by me to *Diodon hystrix*.

1. *D. punctatus* Cuvier. "Autour de la queue il y en a quatre (épines) qui la rendent comme prismatique."
2. *D. hystrix* Günther. The upper and lower sides of the tail with two or three pairs of immovable spines."
3. *D. hystrix* Klunzinger. "Der vordere Theil des Schwanzes ist bestachelt, die Stacheln daselbst nicht dicht, die hintere Hälfte desselben nackt. Stacheln neben dem Schwanzrücken je 3-4, an den Seiten des Schwanzes meist 2, und eben so viele neben der Bauchseite des Schwanzes."

4. *D. hystrix* Swain & Smith. "Shorter and stronger spines in front of dorsal, becoming longer again on tail. Length 24½ inches."

c. In specimens referred to *D. hystrix* var. *holacanthus*

1. *D. novemmaculatus*. *sexmaculatus*. *quadrimaculatus*, *multimaculatus*, Cuvier. "La queue n'en a que deux (épines) en dessus."
2. *D. spinosissimus* Günther. "Upper part of the tail with a pair of spines besides those on the sides."
3. *D. maculatus* Günther. "Upper part of tail with a pair of spines besides those on the sides."

d. In specimens examined by me.

1. No. 3728, Mus. Ind. Univ.. from Saint Thomas ; 20 inches long, with 16 spines on tail ; two and a half pairs of spines at base of tail ; no spines on sides ; a series around root of tail ; procumbent spines irregularly placed on upper side (= *hystrix*).
2. No. 3728, Mus. Ind. Univ., from Havana ; 21 inches long, with 15 spines on tail ; 3 pairs form 2 ridges on the sides above. 2 pairs similarly placed below, others about the root of tail (= *hystrix* .
3. No. 876, Mus. Ind. Univ., from Key West ; 19 inches long, with 15 spines on tail ; 5 on lower side ; 4 forming a ridge on one side on top ; 3 with a fourth subdermal spine on opposite side ; none on sides ; the others at the root of the tail (= *hystrix*).
4. No. 1244. Mus. Ind. Univ., from Lower California near San Diego ; 11 inches long with 12 spines on tail, all of them more or less concealed under skin ; 2 pairs on lower side, 3 pairs on upper side ; none on sides ; others at root of tail (= *hystrix*).
5. No. 383, Mus. Ind. Univ., from Havana ; 7 inches long, with 4 spines on tail ; a pair on lower side, a pair on upper (= *holacanthus*).
6. No. 141, Mus. Ind. Univ., from Havana ; 5 inches long, with 5 spines on tail ; a pair on upper side, others at the root of tail (= *hystrix*).
7. No. 3727, Mus. Dr. Jordan, from Havana ; 5½ inches long, with 2 spines on the tail, one on each side above (= *holacanthus*).
8. Specimen from La Paz*† at San Diego ; "8¾ inches long. One spine on either side at the base of caudal peduncle at the middle of the side" (= *holacanthus*).
9. Specimen from La Paz* at San Diego ; "11 inches long. 3 spines along upper edge of caudal peduncle and one at the lower edge" (= *hystrix*).

B. Frontal spines.

e. In specimens referred to *D. hystrix*.

1. *D. punctatus* Cuvier. "Ceux (épines) de la tête en general sont moins longs que ceux du dos et surtout que ceux des flancs."

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* Examined at my request by Miss Rosa Smith.

† This is the specimen mentioned by Jordan & Gilbert, Proc. U. S. Nat. Mus., 1880, 453; 1881, 70, as from near San Diego.

2. *D. hystrix* Günther. "Frontal spines of medium size."
3. *D. maculatus*, var. β, Günther. "The front spines being sometimes shorter than the eye."

f. In specimens referred to *D. hystrix*, var. *holacanthus*.

1. *D. holacanthus* Linnæus. "Aculeis longissimis teretiformibus in capite imprimis collo."
2. *D. spinosissimus* Cuvier, (Les épines) "du dessus de la tête, qui sont aussi longs que ceux des flancs."
3. *D. novemmaculatus*, etc. Cuvier. "Ceux du dos sont assez egaux" (6 inches long).
4. *D. maculatus*, var. *a*, Günther. "Spines, especially those in front, long, much longer than eye." Var. γ. "Frontal spines longer than eye." Var. δ, "Frontal spines longer than eye."

g. In specimens examined.

1. No. 3728. Frontal spines about half length of post-pectoral spines, about as long as eye (= *hystrix*).
2. No. 3229. Frontal spines not half length of post-pectoral spines.
3. No. 876. Frontal spines not half length of post-pectoral spines, shorter than eye (= *hystrix*).
4. No. 1244. Frontal spines about two-thirds as long as post-pectoral spines, little longer than eye (= *hystrix*).
5. No. 383. Frontal spines longer than post-pectoral spines, about twice as long as eye (= *holacanthus*).
6. No. 141. Frontal spines about three-fourths post-pectoral spines, as long as eye (= *hystrix*).
7. No. 3727. Frontal spines a fourth longer than post-pectoral spines (= *holacanthus*).
8. "Nasal spines one and one-fourth times in longest post-pectoral spine" (= *holacanthus*).
9. "All the spines from snout to dorsal much shorter than those behind pectoral" (= *hystrix*).

C. Pre-dorsal spines.

h. In specimens referred to *D. hystrix*.

1. *D. punctatus* Cuvier. "La troisième racine - - - n'est guère que la continuation du piquant principal" (not stated what part of body).
2. *D. hystrix* Günther. Spines "of the posterior part of the back short and broad."
3. *D. maculatus* Günther. "Spines varying in length - - - ; those on the posterior part of the back sometimes fixed by the projecting anterior ridge of the spine."
4. *D. hystrix* Klunzinger. Ich finde immer 3 Wurzeln, die mittlere Wurzel oder die Fortsetzung des Stachels nach vorn ist aber bei den vorderen Stacheln Kurz bei den hinteren wird sie länger und dann oft so lang oder länger als der Stachel selbst."

5. *D. hystrix* Swain & Smith. "Shorter and stronger spines in front of dorsal."

i. In specimens referred to *D. hystrix* var. *holacanthus*.

1. *D. spinosissimus* Cuvier. "Les piquants sont de la même forme (as those of *punctatus*) - - - et a deux racines transverses."
2. *D. spinosissimus* Günther. "All spines long, slender."
3. *D. maculatus* Günther (see above, C. h. 3).

j. In specimens examined.

1. No. 3728. Pre-dorsal spines very short, three-rooted.
2. No. 3729. Pre-dorsal spines short, three-rooted (= *hystrix*).
3. No. 876. Pre-dorsal spines very short. three-rooted (= *hystrix*).
4. No. 1244. Pre-dorsal spines very short, three-rooted (= *hystrix*).
5. No. 383. All spines similar, long, none with three roots (= *holacanthus*).
6. No. 141. All spines more or less three-rooted (= *hystrix*.)
7. No. 3727. Pre-dorsal spines, with the exception of the one immediately in front of dorsal, two-rooted (= *holacanthus*).
8. "The pre-dorsal spines are two-rooted, though a few have a very short prolongation of the base of the spine (= *holacanthus*)."
9. "Pre-dorsal spines conspicuously three-rooted" (= *hystrix*).

2. DIODON MACULIFER.

Diodon maculifer Kaup, "Wiegm. Arch., 229," 1855. Günther. Cat. Fish. Brit. Mus., VIII, 309, 1870 (Cape Good Hope, Cuba). Poey, En. Pisc. Cub., 169, 1875 (copied). Bleeker, L'île Maurice, 23, 1855 (Mauritius).

Habitat.—Southern seas.

This species seems to be distinguished from its congeners by its longitudinally compressed spines. It is possibly merely a variation of *hystrix*. Klunzinger (as also Swain and Smith) describes his *hystrix* as having the spines somewhat compressed. Several others speak of compressed spines, but the descriptions are not definite enough to warrant the reference of *D. maculifer* to the synonymy of *D. hystrix*. Günther records *D. maculifer* from Cuba, but Poey has not found it there. The species is known to me only from the description of Günther.

2. CHILOMYCTERUS.

Diodon Linnæus, Syst. Nat., Ed. X, 335, 1758 (in part).
Les *Chilomyctères* Bibron, Mss. Barneville, Revue Zoölogique, 1846, 140.
Chilomycterus Kaup, Wiegm. Arch., 365, 1847 (*antennatus*).

Cyclichthys Kaup, Wiegm. Arch., 231, 1855 (*orbicularis*).
Cyanichthys Kaup, Wiegm. Arch., 231, 1855 (*cæruleus*).
Diodon Bleeker, "Atl. Ichth. Gymnod.," 55, 1865 (*atinga*).

This genus is well characterized by the form of the spines, which are all broad, three-rooted and immovable.

ANALYSIS OF THE SPECIES OF CHILOMYCTERUS.

a. Superciliary spines two, with generally a tentacle between them ; a spine in middle of forehead.
  b. Superciliary edge raised ; fins unspotted.
    c. Upper parts dark greenish, with a series of white and bluish lines running from nape backwards ; a similar series between eyes and across face ; an ocellated black spot above pectoral ; a larger one behind pectoral ; an ocellated spot on each side of dorsal, and an elongated spot behind each of the ventral antennæ. Schœpfi, 3.
    cc. Upper parts plain, without a series of lines ; spots as in *Schœpfi.* Spinosus, 4.
  bb. Superciliary edge not raised ; upper parts with numerous black dots, some with a bluish centre ; a black spot in the middle of nape ; a large kidney-shaped spot above the pectoral, and a subtriangular blotch before and along the base of the dorsal fin ; a series of antennæ along the lower part of the side. Antennatus, 5.
aa. Supraorbital spines three, feeble ; none on forehead. Upper parts densely covered with small, round, blackish-brown spots ; a large black blotch before and around dorsal ; another on each side above gill-opening and pectoral ; spines short, compressed, anterior root flat, longer than the others. - - Reticulatus, 6.

3. CHILOMYCTERUS SCHŒPFI.

The Toadfish, Schœpf, "Schriften Berlin. Gesellsch. Naturf. Freunde, VII, 192," 1788 (Long Island).
Diodon schœpfi Walbaum, Artedi, Pisc., 601, 1792 (after Schœpf).
?*Diodon meulini* Walbaum, Artedi, Pisc., 602, 1792 (no locality).
Diodon geometricus var. *lineatus* Bloch & Schneider, Ichth., 513, 1801 (after Schœpf).
Chilomycterus geometricus Kaup, Wiegmann's Archiv, 1847. Gill, Cat. Fish. E. Coast N. Am., 1861. Poey, Syn. Pisc. Cub., 430, 1868 (Cuba). Var. *a* & *β*, Günther, Cat. Fish. Brit. Mus., VIII, 310, 1870 (American waters). Cope, Trans. Amer. Phil. Soc., 480, 1870 (Tortugas). Gill, Cat. Fish. East Coast N. Am., 15, 1873 (Vineyard Sound). Poey, Enum. Pisc. Cub., 171, 1875. Jordan & Gilbert, Proc. U. S. Nat. Mus., 1878, 366 (Beaufort Harbor). Goode, Proc. U. S. Nat. Mus., 1879, 109 (Mouth of St. John, Indian River). Goode & Bean, Proc.

U. S. Nat. Mus., 1879. 122 (Pensacola, Fla.). and 1879, 333 (Key West). Jordan, Proc. U. S. Nat. Mus., 1880, 18 (Indian River, Fla.). Bean, Proc. U. S. Nat. Mus., 1880, 75 (Noank, Conn.; East Shore. Va.; Beaufort, N. C.; Fort Macon, N. C.; Coast New England; Newport, R. I.). Jordan & Gilbert, Proc. U. S. Nat. Mus., 1882, 241 (Galveston); and 1882, 619 (Charleston, S. C.). Jordan & Gilbert, Syn. Fish. N. Am, 863, 1883. Bean, Coll. Fish. Internat. Exh. London, 42, 1883 (Pensacola). Jordan, Proc. U. S. Nat. Mus., 1884, 146 (Key West). Id., Cat. Fish. N. Am., 141, 1885 (name only).

Le Diodon orbe Lacépède, "Poissons, II, page —," 1798 (Rio Janeiro).

Diodon maculostriatus Mitchill, Fish. New York, 470, plate LVI, fig. 3, 1814 (New York). DeKay, Nat. Hist. New York, Fishes, 323, plate LVI, fig. 185, 1842 (New York). Ayres, Boston Journal Nat. Hist., IV, 284, 1842 (Brookhaven, Long Island).

Diodon rivulatus Cuvier, Mem. Mus. Hist. Nat., IV, 129, plate VI, 1818; Id., Règne Animal, Ed. II, 337 (note), 1829.

Diodon nigrolineatus Ayres, Boston Journal Nat. Hist., IV, 68, 1842 (Brookhaven, Long Island).

Diodon fuliginosus De Kay, Nat. Hist. New York, Fishes, 324, plate LV, fig. 181, 1842 (New York; young).

Chilomycterus geometricus subsp. *fuliginosus* Jordan & Gilbert, Syn. Fish. N. Am., 864, 1883 (young).

Chilomycterus fuliginosus Jordan, Cat. Fish. N. Am., 441, 1885 (name only).

Diodon verrucosus DeKay, Nat. Hist. New York, Fishes, 325, plate LVI, fig. 184, 1842 (New York).

Chilomycterus sp. dubia, "An *Chylomycterus fuliginosus?*" Poey, Syn. Pisc. Cub., 429–30, 1868 (Havana).

Habitat.—New England to West Indies.

This species is readily recognized by the dark and light lines of the upper parts. The lines are parallel and meet towards the back. A reticulation is sometimes formed when these lines meet on the anterior part of the back. In the young there seem to be more lines than in the old. Two specimens examined, 3 inches long, have 17 lines between the pectorals; a specimen 5 inches long has 10 lines; and the largest specimen examined, 10 inches long, has 12 lines.

Dr. Jordan has identified the *schœpfi* of Walbaum with the present species. Walbaum in his description of *schœpfi* says, "color in dorso fulvus, lineis albis longitudinalibus notatus;" as the other part of the description agrees quite as well, the name *schœpfi* has been substituted for *geometricus*, which name in fact belongs to the next species rather than to this, if the two be different. DeKay has well figured and described the young of this species under the names *fuliginosus* and *verrucosus*.

The many specimens examined by me are from Beaufort, N. C., and from Key West.

4. CHILOMYCTERUS SPINOSUS.

Guamaicu atinga Marcgrave, Hist. Nat. Bras., 168, 1648 (*in mari*).

Ostracion subrotundus ventre glabro Artedi, Gen., 59, No. 15. Sueci Desc Spec. Pisc., 86, No. 18 (based on Marcgrave).

Diodon spinosus Linnæus, Syst. Nat., Ed. X, 335, 1758 (India; based on Artedi).

Cyclopterus lumpus var. *β*, Linnæus, Syst. Nat., Ed. XII, 414, 1766.

Diodon geometricus Bloch & Schneider, Ichth., 513, plate 96, 1801 (America).

Cyclichthys cornutus Kaup, "Wiegm. Arch., 231," 1855 (Bahia).

Chilomycterus geometricus var. *γ*, Günther, Cat. Fish. Brit. Mus., 311, 1870 (Brazil; Bahia, the latter the type of *C. cornutus* Kaup).

Habitat.—West Indies and coast of Brazil.

This species, according to Günther, differs from *schœpfi* only in the coloration, the lines on the back being absent. Marcgrave gives a figure and description which certainly refer to the same fish. Artedi bases his description on Marcgrave, and this account in turn is the basis of the *spinosus* of Linnæus.

I have seen no specimens of this species, which would seem to be a southern representative of *Ch. schœpfi*. Perhaps the two may be color-variations of the same species, in which case the name *spinosus* must be adopted.

5. CHILOMYCTERUS ANTENNATUS.

Diodon antennatus Cuvier, Mem. Mus., IV, 131, plate VII, 1818. Id., Règne Animal, 337 (note), "plate IX, fig. 1," 1829.

Chilomycterus antennatus Kaup, "Wiegm. Arch., 232," 1855. Günther, Cat. Fish. Brit. Mus., VIII, 311, 1870 (St. Croix; Jamaica; Cape Good Hope). Bean & Dresel, Proc. U. S. Nat. Mus., 1884, 151 (name only).

Chilomycterus puncticulatus Poey, Anal. Hist. Nat., 346, 1881 (Porto Rico).

Habitat.—Southern seas of America.

This species is characterized by the tentacles along the side, by the coloration, and by the colorless fins. It is known to me only from descriptions.

6. CHILOMYCTERUS RETICULATUS.

Ostracion subrotundus Artedi, Gen., 59, No. 16. Sueci, Desc. Spec. Pisc., 86, No. 19, 1738.

Crayracion No. 16, Klein, Historia Pisc., 20, 1740 (after Artedi).

Diodon reticulatus Linnæus, Syst. Nat., Ed. X, 334, 1758 (after Artedi). Gmelin, Syst. Nat., 1449, 1788 (copied). Lowe, Fish. Madeira, 87, plate 13, 1843–60.

Chilomycterus reticulatus (Bibron Mss) Barneville, "Revue Zoöl., 141," 1846. Bleeker, "Atl. Ichth., V, 54," 1865. Günther, Cat. Fish. Brit. Mus., VIII, 313, 1870 (St. Helena ; Bermudas). Poey, Enum. Pisc. Cub., 171, 1875. Goode, Bull. U. S. Nat. Mus., V, 21, 1876. Jordan & Gilbert, Syn. Fish. N. Am., 969, 1883 (Florida Reefs). Jordan, Cat. Fish. N. Am., 141, 1885 (name only).

Diodon atringa var. *reticulatus* Walbaum, Artedi, Pisc., 596, 1792.

Diodon atinga var. *reticulatus* Walbaum, Artedi, Pisc., 596, 1792 (copied).

Diodon atinga β, Linnæus, Syst. Nat., Ed. XII, 413, 1766 (India).

?*Diodon atinga* var. *orbicularis* Walbaum, Artedi, Pisc., 588, 1792 (Pacific and Indian Ocean).

Diodon hystrix var. *orbiculatus* Bloch & Schneider, Ichth., 512, 1806 (Jamaica).

Diodon tigrinus Cuvier, Mem. Mus., IV, 127, plate VI, 1818. Id., Règne Animal, Ed. II, 337 (note), 1829.

Diodon atinga Poey, Syn. Pisc. Cub., 429, 1868.

Chilomycterus orbitosus Poey, Annals Lyc. Nat. Hist. New York, 1875, 69 (Cuba). Id., Enum. Pisc. Cub., 171, 1875 (Havana).

Habitat.—West Indies north to Bermuda and the Florida Keys.

The *Diodon reticulatus* differs from *antennatus* in the absence of the antennæ, and in the coloration. The fins especially are marked with small black spots.

This species is well known to naturalists, but I have not been able to examine it.

List of Nominal Species of Diodontidæ in Chronological Order, with Identifications.

[Tenable specific names are in *italics*.]

1.	Diodon *reticulatus* Linnæus,	1758	Chilomycterus reticulatus.
2.	Diodon *spinosus* Linnæus,	1758	Chilomycterus spinosus
3.	Diodon *hystrix* Linnæus,	1758	Diodon hystrix.
4.	Diodon *holacanthus* Linnæus,	1758	Diodon holacanthus.
5.	Cyclopterus lumpus var. β, Linnæus,	1766	Chilomycterus spinosus.
6.	Diodon atinga orbicularis Walbaum,	1892	Chilomycterus reticulatus.
7.	Diodon *schœpfi* Walbaum,	1792	Chilomycterus schœpfi.
8.	Diodon meulenii Walbaum,	1792	Chilomycterus schœpfi.
9.	Le Diodon plumier Lacépède,	1798	Diodon hystrix.
10.	Le Diodon tacheté Lacépède,	1798	? Diodon holacanthus.
11.	Le Diodon orbe Lacépède,	1798	Chilomycterus schœpfi.
12.	Diodon brachiatus Bloch & Schneider,	1801	Diodon hystrix.
13.	Diodon geometricus Bloch & Schneider,	1801	Chilomycterus schœpfi.
14.	Diodon geometricus lineatus Bloch & Schneider,	1801	Chilomycterus spinosus.
15.	Diodon liturosus Shaw,	1804	? Diodon holacanthus.
16.	Diodon echinus* Rafinesque,	1810	Diodon hystrix.
17.	Diodon maculostriatus Mitchill,	1814	Chilomycterus schœpfi.
18.	Diodon pilosus Mitchill,	1814	? Diodon holacanthus.
19.	Diodon tigrinus Cuvier,	1818	Chilomycterus reticulatus.
20.	Diodon rivulatus Cuvier,	1818	Chilomycterus schœpfi.
21.	Diodon *antennatus* Cuvier,	1818	Chilomycterus antennatus
22.	Diodon punctatus Cuvier,	1818	Diodon hystrix.
23.	Diodon spinosissimus Cuvier,	1818	Diodon holacanthus.
24.	Diodon novemmaculatus Cuvier,	1818	? Diodon holacanthus.
25.	Diodon sexmaculatus Cuvier,	1818	? Diodon holacanthus.
26.	Diodon quadrimaculatus Cuvier,	1818	? Diodon holacanthus.
27.	Diodon multimaculatus Cuvier,	1818	? Diodon holacanthus.
28.	Diodon fuliginosus DeKay,	1842	Chilomycterus schœpfi.
29.	Diodon verrucosus DeKay,	1842	Chilomycterus schœpfi.
30.	Diodon nigrolineatus Ayres,	1842	Chilomycterus schœpfi.
31.	Diodon melanopsis Kaup,	1855	? Diodon holacanthus.
32.	Diodon *maculifer* Kaup,	1855	Diodon maculifer.
33.	Cyclichthys cornutus Kaup,	1855	Diodon spinosus.
34.	Diodon maculatus Günther,	1870	Diodon hystrix & holacanthus.
35.	Chilomycterus orbitosus Poey,	1875	Chilomycterus schœpfi.
36.	Chilomycterus puncticulatus Poey,	1881	Chilomycterus antennatus.

* Rafinesque, Indice, 58, 1810 (Catania ?; young).

Indiana University,
Dec. 7, 1885.

XVI.—*Description of a New Species of Aplodontia, from California.*

BY C. HART MERRIAM.

Read March 15, 1886.

Up to the present time but a single representative of the somewhat remarkable family *Haplodontidæ* of Lilljeborg has been recognized by naturalists. This is the Sewellel of Lewis and Clark (1814), upon whose description Rafinesque's *Anisonyx rufa* (1817) was wholly based. Subsequently (in 1829) Richardson correctly characterized the animal and gave it the name *Aplodontia leporina*, by which it has been designated by most American writers. Rafinesque's generic term *Anisonyx* has been rejected because it had already been applied to a species of *Cynomys* by the same author,* but his specific name *rufa*, as suggested by Baird and adopted by Coues, must be accepted as the proper specific name of the species.

This singular animal, which has come down to us as a relic of

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* Rafinesque characterized the genera *Cynomys* and *Anisonyx* on the same page, the former name occurring first. The genus *Cynomys* was framed for the reception of the "Barking Squirrel" of Lewis and Clark, now commonly known as the "Prairie Dog"—the *Cynomus ludovicianus* of recent writers. The genus *Anisonyx* was framed for the reception of the "Burrowing Squirrel" of Lewis and Clark, since ascertained to be another species of Prairie Dog—the *Cynomys columbianus* of recent writers—and hence becomes a synonym. To this genus was referred, though not without hesitation, the Sewellel of Lewis and Clark. Following is the whole of Rafinesque's account of it: "*Anisonyx ? rufa.* Raf. Fur long, silky, entirely reddish brown, ears short, pointed with short hair.—Obs. This animal called Sewellel by Capts. Lewis and Clark, is of a doubtful genus, since they only saw the fur of it; it burrows and runs on trees like the ground squirrels; length eighteen inches, found in neighborhood of the Columbia River."—American Monthly Magazine, Vol. II, 1817, p. 45.

the past, and which has no near affinities with any existing group, inhabits a narrow strip of country on the north-west coast of the United States. It is not known from the region east of the Cascade Range,* and all the specimens thus far obtained have come either from Oregon or Washington, or from the Chilukweyuk River near its junction with the Frazer, just across our border in British Columbia.

Rumors have from time to time appeared to the effect that a Sewellel or Show'tl lived in the mountains of California, but the only animal purporting to have been taken within the limits of that State which has actually fallen under the eye of a naturalist, so far as I have been able to ascertain, is one which reached the Museum of the University of Berlin twenty-two years ago. This specimen will be discussed at length later in the present paper.

In June, 1885, Mr. C. A. Allen, who was collecting mammals for me in California, wrote as follows: "There has just been discovered, about twenty-five miles from here, an animal which I have for years been trying to secure. It is what the mountain people in the Sierras call a 'Mountain Beaver.' A man has caught six alive in his garden, and all were thrown away except one, which was sent to the Academy of Sciences in San Francisco. I am wild to see one. I offered a miner $5.00 for one when in the Sierras two years ago, but he failed to get it. - - - I have seen their holes. They inhabit springy side-hills where they burrow and make their homes. They are very shy animals, and are probably nocturnal,—at least I judge so from not having been able to see them in my searches after them. I am told that they have no tail, or at most a slight apology for one." This description, meagre and aggravating as it was, satisfied me that

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* I am aware that Newberry, in the XII Vol. of the Pacific Railroad Reports, states that he saw an "absolutely black" specimen which was "obtained near the base of the Rocky Mountains" (No. 2, Reports upon the Zoology of the Route. By J. S. Newberry, M. D., Chapter I. Report upon the Mammals, 1859, p. 58). But since the same sentence contains an obvious mistake, and since no other naturalist has recorded the species from the region between the Cascade Range and the Rocky Mountains, it seems safe to assume that Newberry's record was based on faulty information.

the animal in question must be a species of *Aplodontia,* and I urged Mr. Allen to exert himself to the utmost to secure specimens of it. This he was not able to do in the locality above alluded to, which was near the coast in Marin County.

Later in the season, at my request, he made a special trip about 150 miles to the eastward of the former locality, and spent two weeks collecting in the heart of the Sierra Nevada Mountains of Central California, in Placer County. Here his efforts were rewarded by the capture of no less than eight specimens of the so-called 'Mountain Beaver,' representing both sexes and various ages. Their carefully prepared skins and skulls, with four skeletons, reached me in December last, and but a glance was necessary to show that they were distinct from the only previously described species. Hence the following facts, contributed by Mr. Allen, are of much interest.

The length of the adults in the flesh was 16 inches, and their weight four pounds. The tail was "about an inch long and all fur." The eyes were very small.

"The animals live in small colonies and inhabit wet ground where there is plenty of running water. None were found away from water. They are very compact and strong, with a head which resembles that of a 'pug' dog. They are very shy, timid animals. On first seeing a human being, they try to hide away, but on being aroused are savage enough. They bite fearfully. I gave one a stick to take hold of, and by that means pulled him out of his hole. One got hold of my hunting-shoe and broke off one of the teeth in his under jaw against the big nails in the sole. I was trying to get him out of the trap to bring home alive, but he was so ugly and bit everything so ferociously that I was obliged to kill him.

"I find that they come out of their burrows about sundown to get their food, and again at daylight in the morning. I do not think they move about during the day, as I watched about one of their places several hours, but could not see or hear a movement.

"The Sewellel's food is in large part composed of aquatic plants. They are very fond of a species of lily that grows along the margins of the small streams ;—I do not know that they dive down and get the roots, but the stems and leaves they cut off and carry to their burrows. They eat the stem part and throw away the broad leaf, which is twelve inches in diameter, heart-shaped, and grows to the height of twenty inches or more. The reason I said that these animals resemble the muskrat is because they live about the water all the time; their burrows are always on a low hill-side in the cañons or gulches where the ground is springy or boggy, the wetter the better. In fact, the spring water can be seen running down through most of the holes, and nearly all the animals secured were caught in traps set in the water. They cannot be found away from water in the Sierras. They are not very particular as to what they eat. I saw willows, red osiers, small fir trees, wild lilies, manzanita bushes, and various other plants cut by them. I found small fir trees four feet high with every limb cut off to the top; also small willows and manzanita bushes pruned of their limbs as high as three and four feet. These limbs and other vegetable substances they carry to the mouths of their holes and drag just inside of the entrance to eat in safety under cover. That they can and do climb small trees and bushes, which have plenty of limbs, I am well assured. They can grasp and hold anything in their feet as well as a monkey. One that was in a trap took hold of a limb of a small willow tree, and I had to pull very hard to tear it away."*

Comparison of the eight specimens sent me by Mr. Allen, from the Sierra Nevada Mountains of Central California, with a still larger series from Oregon and Washington, reveals many points of difference. These differences are shown in absolute size, size of fore and hind feet, size of ear, character and color of pelage, color of whiskers, and in cranial and skeletal characters.

The above-mentioned differences are marked and constant, and no animals in any way intermediate are known to exist. Hence I have no hesitation in describing the newly-discovered California animal as a distinct species, designating it as follows:

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* For remarks on the habits of *A. rufa*, the reader is referred to the writings of Suckley, Newberry, Gibbs, and Cooper, in the twelfth volume of the Pacific R. R. reports; to an interesting chapter by John Keast Lord in his "Naturalist in Vancouver Island and British Columbia" (vol. I, 1866, pp. 346–358); and to articles by Matteson and Lum in the American Naturalist, vol. XI, 1877, pp. 434–435, and vol. XII, 1878, pp. 10–13.

APLODONTIA MAJOR sp. nov.

CALIFORNIA SHOW'TL; "MOUNTAIN BEAVER."

Diagnosis.—Length about 400 mm.; hind foot with claws about 60 mm.; height of ear about 8 mm.

Pelage comparatively coarse and harsh; hairs of flanks longer than those of the surrounding parts, forming on each side a more or less pronounced oval patch from 60–80 mm. in length and 40–60 in breadth, which terminates abruptly about opposite the hip-joint, and which is most marked in specimens not fully adult.

Color.—Whiskers black; back grizzled grayish-brown, the tint of the brown being that of a dilute bistre; hairs at base, and the under fur, very dark plumbeous; rump and belly grizzled mouse gray, sometimes faintly and superficially washed with very dilute brown; a distinct patch of white in the anal region; tip of nose sooty-brown, which color sometimes extends backwards in a narrow stripe almost to a point midway between the eyes.

DIFFERENTIAL DIAGNOSIS BASED ON EXTERNAL CHARACTERS.

APLODONTIA RUFA.	APLODONTIA MAJOR.
Length of head and body about 340 mm.	Length of head and body about 400 mm.
Hind foot with claws about 53 mm.	Hind foot with claws about 60 mm.
Height of ear from crown about 10 mm.	Height of ear from crown about 8 mm.
Pelage comparatively fine and soft.	Pelage comparatively coarse and harsh.
Long hairs of the sides not forming a distinct flank patch, and not ending abruptly posteriorly.	Long hairs of the sides forming a more or less pronounced flank patch, which posteriorly ends abruptly opposite the hip joint.
Whiskers white.	Whiskers black.
Back pale burnt-umber largely mixed with black-tipped hairs, the burnt-umber becoming lighter and brighter on the sides and flanks.	Back grizzled grayish-brown (tint of brown dilute bistre) which color terminates posteriorly about opposite the hip joints.

Hairs at base plumbeous.	Hairs at base very dark plumbeous.
Belly mouse-gray, strongly washed with dilute umber.	Rump and belly grizzled mouse-gray, the latter sometimes faintly washed with very dilute brown.
No distinct patch of white in anal region.	A distinct patch of white in anal region.

Cranial Characters.—The material before me consists of sixteen skulls—eight of *Aplodontia major* and one of *A. rufa* from my own collection, and seven of *Aplodontia rufa* from the U. S. National Museum.* These skulls represent both sexes and various ages. Of the eight skulls of *A. major*, four are males and four females. Of these, two of the males and three of the females are adults, there being two young males and one young female. Of the eight skulls of *A. rufa,* three (Nos. 3891, 3942, and 11358 U. S. Nat. Mus.) are fully adult—in fact old—and they are doubtless males. The remaining five are more or less immature and pertain to both sexes. Two of them are too much broken to furnish complete tables of measurements. In the following comparisons, the skulls of adult males only are referred to, unless the contrary is stated.

Comparison of the skull of *Aplodontia major* with that of *A. rufa* shows several points of difference, though none of much taxonomic value. In absolute size *A. major* is much the larger. The average of the basilar-length in the two adult males is 68.85 mm., and of the zygomatic breadth 62.35 mm. ; while the average basilar-length in the three adult skulls of *A. rufa* is 64.20 mm., and the zygomatic breadth 55.66 mm. Coupled with this increase in size, is a marked increase in the weight of the skull† and in the development of its processes, ridges and muscular impressions. While the skull of *A. major* has come to be much

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* For the privilege of examining these specimens, I am indebted to Prof. S. F. Baird, Director of the U. S. National Museum, and Mr. F. W. True, Curator of Mammals.

† The largest and heaviest skull of *A. rufa* that I have examined weighs a little less than 16 grams, while the largest of *A. major* weighs nearly 24 grams.

larger than that of *A. rufa*, the teeth have remained of the same absolute size, the differences noted being merely those of individual variation. Thus the ratio of the molar series (measured on the crowns) to the basilar-length is 26.20 in the largest skull of *A. major*, and 28.59 in the largest of *A. rufa*.

The occipital crest is much more pronounced in *A. major*, giving the posterior aspect of the cranium a contour quite different from that of *A. rufa*. The greater height of the occipital crest in *A. major* is relative as well as absolute, the ratio of its vertical height from the apex of the paroccipital process in an adult male being 37.09, while in the largest male of *A. rufa* this ratio is but 29.38.

The zygomatic arches furnish some of the best cranial characters in distinguishing the two species. The jugal bones are not only twice as thick and heavy in *A. major* as in *A. rufa*, but they are farther apart anteriorly,* and the arches are more bowed outward, giving the skull a very different outline. Moreover, the vacuities which they enclose differ in shape and relative size in the two species. Viewed from above, they are shorter and broader in *A. major*; measured from below, their absolute length is the same in both, notwithstanding the fact that the skull of *A. rufa* is so much smaller. Hence the ratio of the greatest length of the zygomatic vacuity to the basilar-length is 37.68 in *A. major* and 39.63 in *A. rufa*.

The post-zygomatic notch is a trifle narrower and deeper in *A. major* than in *A. rufa*.

The length of the frontal and parietal together, and the ratio of this length to the basilar-length, are considerably greater in A. *major* than in *A. rufa*.

The length of the ascending or frontal process of the premaxillary is about the same in the two species, notwithstanding the

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* This greater breadth across the maxillary roots of the zygomæ affects somewhat the position of the ant-orbital foramina. They are set out farther from the muzzle in *A. major* than in *A. rufa*. The average of the least distance between them in the largest four skulls of *A. major* is 18.47 mm.; while in the three largest of *A. rufa* it is 16.03 mm. The ratio of these averages to averages of the basilar-length in these same skulls, is 27.01 in *A. major* and 24.92 in *A. rufa*.

difference in the size of the skulls. Hence it appears that the ratio of the average length of this portion of the premaxillary to the average of the basilar-length, in four skulls of *A. major*, is 36.12; while in four skulls of *A. rufa* it is 39.60.

In all of the skulls of *A. major* excepting the youngest (No. 2103 Mus. C. H. M.) the nasals terminate posteriorly either exactly or nearly on a line with the premaxillaries. In the young male No. 2103, they fall short of this line by 2 mm. The contrary is true in the series of eight skulls of *A. rufa.* Here the nasals normally fall short of the fronto-premaxillary suture by from 1 to 5 mm., in exceptional cases only ending flush with it. Still, since both conditions are found in both species, this character cannot be regarded as distinctive.

But the nasal bones furnish another character apparently more constant than the foregoing. In adult males of *A. major*, the greatest breadth of the nasals is at or near their anterior extremities, while in *A. rufa* it is situated some distance posteriorly—usually about 8 or 10 mm. from the anterior end of the bone. In the specimens before me, this difference is very marked, and the greatest breadth in *A. rufa* is absolutely as well as relatively greater than the measurement of the corresponding part in *A. major.* For example, in the largest skull of *A. rufa* (No. 11358 U. S. Nat. Mus.) the nasals anteriorly measure 11.90 mm. At a point 10 mm. posteriorly their breadth is 13.40 mm. In the largest male of *A. major* (No. 2106 Mus. C. H. M.) these measurements are respectively 12.60 mm. and 12 mm. Hence at a point 10 mm. from the front end of the nasals, the breadth of those of *A. rufa* is actually 1.40 mm. greater than those of *A. major*, while the skull of the latter is much the larger.

In brief, skulls of *A. major* are distinguishable from those of *A. rufa* (1) by absolute size; (2) by absolute weight; (3) by the ratio of the upper molar series to the basilar-length; (4) by the contour of the occiput and the development of the occipital crest; (5) by the distance between the antorbital foramina; (6) by the shape of the zygomatic arches and of the vacuities which they enclose; (7) by the shape of the nasal bones, and by the ratio of their length to that of the ascending process of the premaxillary; (8) by the ratio of the ascending process of the premaxillary to the basilar-length; (9) by the distance between the antorbital foramina; and (10) by the fronto-parietal length.

Geographical Distribution.—Very little can be said concerning the geographical distribution of *Aplodontia major*, since the only known specimens came from Placer County, California.* The animals mentioned by Mr. Allen as having been taken in Marin County, may or may not belong to the present form. The same remark applies to a species of *Aplodontia* which, as I am told by Mr. C. H. Townsend, who has recently visited the region, inhabits portions of Siskiyou and Lassen Counties, in the northern part of the State, where, also, it is called 'Mountain Beaver' by the hunters. Unfortunately, no specimens were obtained.

Mr. S. K. Lum, in an article on the habits of *Aplodontia rufa*, states: "In Southern Oregon, it is found in moist situations on the tops of the Siskiyou and Rogue's River Mountains, and is there called 'mountain beaver.'"† In the absence of specimens, it is impossible to say to what species these animals pertain. The localities mentioned, however, are not far distant from Coquille, Coos County, Oregon, where Dr. Matteson has obtained specimens of *A. rufa* §

In the present state of knowledge, it is safe only to say that representatives of the genus *Aplodontia* inhabit the Pacific coast region from about lat. 50°, in British Columbia, southward at least to lat. 38° 35′, in central California. The geographical distribution of these animals is peculiar: like the Columbia deer, and certain birds, they are restricted on the East by the eastern bases of the Cascade Range and Sierra Nevada Mountains; while on the West they extend nearly or quite to the coast.

HISTORY AND NOMENCLATURE.

The present species, fortunately, is not encumbered with a long, involved synonymy; and its history is simple.

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* Since this article has been put in type, the U. S. National Museum has received two imperfect skins of my new species from Lieut. P. H. Ray, who obtained them from the Indians in Hoopa Valley, in northwestern California.

† American Naturalist, Vol. XII, 1878, p. 10.

§ Ibid, Vol. XI, 1877, p. 434.

In 1854 Audubon and Bachman, writing of the Washington Show'tl, remarked that it "has also been procured in California,"* but on what authority this statement was based does not appear. Three years later Baird said: "I have heard of an *Aplodontia* from California, probably the same species, but have not seen a specimen."†

The Proceedings of the California Academy of Natural Sciences for 1866 (Vol. III, p. 224) contains a record of the donation to the Society's cabinet of a "Specimen of *Aplodontia leporina*, shot near lake Tahoe, by Mr. J. M. M'Donald." This specimen was presented at the regular meeting held September 18, 1865. No farther details are given, and since Lake Tahoe occupies portions both of California and Nevada, it is uncertain from which State the animal came. The probabilities are, however, that it was killed in Placer County, California, this being the region from which my specimens were procured.‡

The specimen previously mentioned as having been sent to the Berlin Museum, was described by the late Dr. W. Peters in the *Monatsberichte der Königl. Preuss. Akademie der Wissenschaften zu Berlin,* 17 *März,* 1864, *pp.* 177–179. His de-

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* Quadrupeds of North America, Vol. III, 1854, p. 102.

† North American Mammals, 1857, p. 354.

‡ In the first volume of the above-mentioned Proceedings, under the head of donations made to the Cabinet at the meeting held September 24, 1855, occurs the following paragraph: "From Mr. E. C. Gibbes, an animal from the vicinity of the 'Great Trees,' Calaveras County. It is a species of Marmot, perhaps undescribed, but the specimen is too imperfect for a close comparison. Better specimens will probably soon reach us, as the species is quite common in that portion of the State. The miners call it *Mammoth Mole.*" (Proc. Cal. Acad. Natural Sciences, Vol. 1, 1854–57, p. 71 of the original ed.; p. 76 of reprint.)

Concerning the above specimen, the venerable Dr. J. G. Cooper has written me, under date of February 7, 1886: "I was present and saw this skin, and compared it soon after with that of the *Aplodontia* [from Astoria] presented Oct. 15th [by Lt. W. P. Trowbridge]. All thought it the same animal, though some differences noticed might prove it to be the Marmot [*Arctomys flaviventer*] well known from higher elevations. I will see if the specimen still exists."

scription is so important in the present connection that I make no apology for quoting it verbatim.

"*Haplodon* (*Aplodontia*) Richards. Von dieser merkwürdigen Gattung kennt man bis jetz nur eine Art aus dem westlichen Theile von Nordamerika am Puget-Sunde, den *H. leporinus* Richards., welcher neuerdings von Hrn. Spencer F. Baird (*Mammals of North America*, Philadelphia. 1859, p. 353) genauer beschrieben und mit dem Biber in eine Familie zusammengestellt worden ist, während Hr. Brandt dieselbe den *Sciurini* als eine besondere Unterfamilie mit wurzellosen Zähnen anreiht. Unser Museum hat neuerdings ein Fell nebst Schädel aus den Gebirgen Californiens erhalten, und hiernach muss ich mich der Ansicht Brandt's mehr anschliessen. Der Unterkiefer stimmt im Wesentlichen ganz mit dem von *Arctomys* überein. wenn man davon absieht, dass der hintere Winkel desselben eigenthümlich verbogen erscheint. Die Foramina incisiva liegen wie bei den *Sciurini* nur zwischen den Zwischenkiefern und die Foramina infraorbitalia sind mässig gross, kaum grösser als bei den *Tamias*. Der allenthalben gleich breite Gaumen, die Flügelbeingruben und die Gehörbullen sind ganz ähnlich wie bei *Arctomys*. Der vordere aufsteigende Theil des Jochbeins verbindet sich mit einem gleich breiten Theil des Thränenbeins, in ähnlicher Weise wie bei *Xeros*, mehr noch wie bei den *Chinchillina*. Die Unterschenkelknochen sind getrennt; leider wissen wir aber noch immer nichts von dem inneren Bau, nicht einmal ob Schlüsselbeine und Blinddarm, wie es wahrscheinlich ist, entwickelt sind. Ob das uns vorliegende Exemplar wirklich zu *H. leporinus* gehört, ist nicht ganz sicher. Auffallend ist jedenfalls ein ziemlich grosser (15 bis 20 Mm. im Durchmesser haltender) rundlicher regelmässiger weisser Fleck an jeder Körperseite, ganz nahe vor dem Oberschenkel, dessen bei der Beschreibung jener Art nicht erwähnt wird. Es entsteht dieser Fleck dadurch, dass die Wollhaare an dieser Stelle etwas verlängert und mit weisser Spitze versehen sind, so dass ich vermuthete, es möchte am Grunde desselben vielleicht eine Drüse ausmünden. Dagegen spricht jedoch, das die Haare hier ebenso dicht, wie an allen anderen Körperstellen stehen. Auch erscheint der Schwanz viel kürzer; ohne Haar 13 Mm. (6 Lin. Engl.), während derselbe nach Baird bei *H. leporinus* 10 Lin. lang ist. Er könnte jedoch an dem einzigen Exemplar verstümmelt sein, obgleich es den Anschein hat, als sei er unverletzt. Der Schädel zeigt, mit der von Baird gegebenen Abbildung verglichen, sich darin auffallend verschieden dass die obere Backzahnreihe nicht auffallend kürzer, sondern ganz gleich ist der Entfernung der Schneidezähne von den Backzähnen, dass der Ausschnitt hinter dem Processus zygomaticus des Schläfenbeins ein viel grösserer ist, das Foramen mentale weiter nach vorn, die hintere öffnung des Canalis inframaxillaris weiter nach hinten liegt und letztere von oben sichtbar ist, dass ferner der Processus coronoideus an seiner Basis breiter erscheint. Ich werde daher wegen dieser Unterschiede, bis die Identität oder Verschiedenheit der Thiere festgestellt sein wird, das Californische als *H. leporinus* var. *Californicus* bezeichnen."

The mere existence of the above description of an *Aplodontia* which is stated to have come from California, at once raises the question of its identity with the present species. If reasonable grounds exist for the belief that the two forms are not separable, Peters's name *Californicus* must of course be accepted as the proper specific name for the subject of the present paper. To determine this point, it is necessary to review somewhat in detail the characters attributed to the Berlin animal.

Peters's comparisons, it must be remembered, were based wholly on Baird's description and plate. Baird's plate of the skull is a fairly good one, and shows quite accurately most of the points spoken of by Peters.

The cranial differences mentioned by Peters are : 1st, that the upper molar series of teeth is of the same length as the distance between the molars and incisors, instead of being considerably less ; 2d, that the post-zygomatic notch is much larger ; 3d, that the mental foramen is farther forward ; 4th, that the posterior opening of the inframaxillary canal is farther behind and is visible from above ; and, 5th, that the coronoid process appears broader at its base.

The first point relates to the length of the upper molar series as compared with the length of the muzzle—a character which in both species varies with the age of the animal. In the adults of both the muzzle is considerably longer than the molar series, while in the young it is equal to or even shorter than the molar series. Hence it is clear that Peters's animal was young, and that the supposed difference was due solely to immaturity.

The second point relates to the size of the post-zygomatic notch, which Peters says is much larger in his specimen than in that figured by Baird. Baird's plate shows very well the size and form of the notch, as it exists in the seven skulls of *A. rufa*. In the California animal this notch is still narrower, though perhaps a trifle deeper; hence in this respect Peters's specimen differs from both.

The third point relates to the position of the mental foramen. Peters says that it opens more anteriorly than shown in Baird's figure. In all of the jaws of both species examined by me (16 in number) this foramen is situated more *posteriorly* than indicated in the above mentioned plate.

The fourth point relates to the position and angle of the opening of the inframaxillary canal—the inferior dental foramen. Peters says that it is situated more posteriorly than indicated in Baird's plate and that it is so placed as to be visible from above. In the specimens examined its position agrees very well with that indicated by Baird; and whether or not the opening can be seen from above depends neither upon age, sex, nor species, but solely upon individual variation—as demonstrated in the series before me. Two specimens of the same age, taken at the same place and on the same date, present the extremes of this peculiarity. In one the opening is distinctly visible from above; in the other it is entirely hidden by the ridge of bone which extends from the condylar process to the posterior alveola.

The fifth point relates to the breadth of the coronoid process at the base. Peters states that it looks broader than in Baird's figure. But since Peters himself did not feel sure upon this point, and since the specimens at hand fail to show any tangible difference in this particular, the character may be safely dismissed.

Three other important points were mentioned incidentally by Peters. The first relates to the size of the infraorbital foramen, which in his specimen was "scarcely larger than in *Tamias*." The smallest infraorbital foramen in the 16 skulls before me is at least three times larger than its maximum condition in any of the skulls of *Tamias* (upward of a hundred in number) in my collection, and the average size of this foramen is larger in the California than the Washington animal.

The second and third points relate to the audital bullæ and pterygoid fossa, which parts Peters states are entirely like those of *Arctomys*. The resemblances in these parts in the two genera are hard to find, while the points of difference are numerous and striking.

It is difficult to understand how a naturalist of Peters's experience could be led to state that much similarity exists between the large, roundish, and somewhat inflated audital bullæ of *Arctomys*, and the small, irregularly flattened, and transversely elongated ones of *Aplodontia*. The pterygoid fossæ are even more dissimilar. In *Arctomys* this fossa is more than twice as long as in *Aplodontia*, it is constricted in the middle, and its walls terminate posteriorly in long hamular processes. Moreover, its anterior boundary bears a long, slender spine which projects backward from the palate. In *Aplodontia* the pterygoid fossa is remarkably short, its sides are parallel, and its anterior boundary is formed by a notch into the palate. Indeed, should the above mentioned resemblances to *Arctomys* really exist, it will be necessary to constitute a new genus for the reception of Peters's specimen.

Turning now from cranial to external chsracters, but two points remain for consideration. The shortness of the tail spoken of ("6 lines") is perfectly normal. Richardson, in his measurements "of a full-grown specimen," gives exactly the same length (6 lines).* Peters used Baird's measurement of 10 lines as his standard of comparison, but Baird expressly stated that his measurements were from a mounted specimen (North American Mammals, 1847, p. 353). However, the tail presents considerable individual variation, sometimes, according to Suckley, attaining the length of 1½ inches; and the material now in hand does not indicate that the tail of *A. rufa* is longer than that of *A. major*.

The white spot on the flanks, which is stated to be 15–20 mm. in diameter, roundish, and symmetrical on the two sides, is a peculiarity which may prove to be characteristic of a very distinct

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* Fauna Boreali-Americana, 1829, p. 212.

animal known as yet from the single specimen in the Berlin Museum, or it may prove to be a case of abnormal individual variation. Be this as it may, no trace of it has been found in any other individual of the genus thus far reported.

Recapitulating, it is found that some of the supposed differential characters attributed to the Berlin specimen are due to age; that others fall within the limits of normal individual variation; while others still are either really distinctive or markedly abnormal. To the latter category belongs the white flank-patch, the most important if not the only external peculiarity. If Peters's description is reasonably accurate, the following cranial characters are distinctive:

1st. Size of post-zygomatic notch.
2d. Position of mental foramen.
3d. Position of dental foramen.
4th. Size of infraorbital foramen.
5th. Size and form of audital bullæ.
6th Size and form of pterygoid fossa.

It may not be out of place here to allude to the geographical source of the Berlin specimen. The only information given by Peters on the subject is that the animal came from "aus den Gebirgen Californiens;" and since at the time this paper was written (22 years ago) the term 'California' was somewhat vaguely applied by most Europeans to the whole west coast region of the United States, it seems safe to assume that very little certainty attaches to this part of the record.

In view of the above facts, brought to light by a somewhat critical analysis of Peters's description, with an ample series of both the Washington and the California animals at hand for comparison, the conclusion arrived at is that the Berlin specimen is widely distinct from the California *Aplodontia* herein described; that it shares several points in common with the original species (*A. rufa*); but that, unless Peters's description is grossly erroneous, it possesses certain distinctive characters which are of sufficient taxonomic importance to demand the establishment of a new genus for its reception.

In concluding this part of the subject it is necessary, perhaps, to say a word in regard to the summary manner in which Peters's animal was disposed of by Coues in his Monograph of the genus. "Professor Peters," writes Dr. Coues, "described specimens from California as constituting a new variety, to which he applied the name *Haplodon leporinus* var. *Californicus*. I have seen no specimens from that region, nor is the material at present available sufficient to enable us to come to final conclusions respecting the normal rate of susceptibility to individual variation. The few specimens, however, indicate that the rate is at least as high as that which has been established for various mammals more or less closely allied; and, should such prove really the case, there would be no impropriety in considering var. *californicus* as strictly synonymous." (Monographs of North American Rodentia, 1877, p. 598.) This statement of Coues contains one error of fact (for Peters had but one specimen—not specimens), and its final assumption was based, doubtless, on a very hasty examination of Peters's description.

CRANIAL DIFFERENCES RESULTING FROM SEX AND AGE.

In placing the adults of *A. major* side by side, the most noticeable sexual difference is found in the suture which separates the frontal bones from the premaxillaries and nasals. This suture is open in the females and closed in the males.

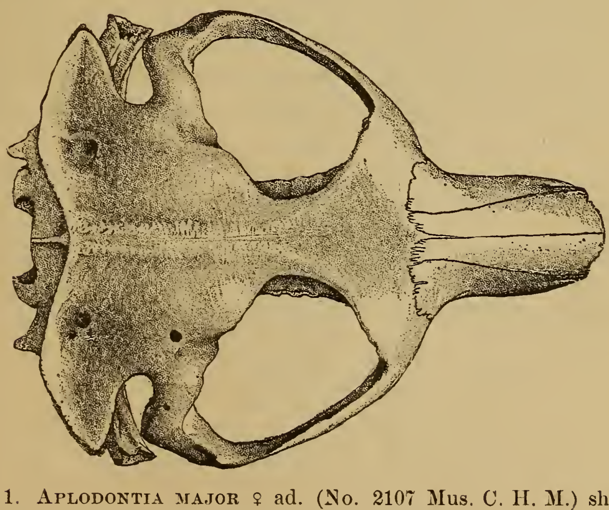


Fig. 1. APLODONTIA MAJOR ♀ ad. (No. 2107 Mus. C. H. M.) showing persistent fronto-premaxillary suture. Natural size.

As a whole, the skull of the female is less heavy and massive than that of the male, and the occipital crest is not so highly developed. The zygomatic arches are not so much bowed outward, and the post-zygomatic notches are larger. In all these points the females show an approach, though distant, to the condition of the adult male of *A. rufa.*

The study of a series of young, with which I am fortunately provided, serves to bridge over very completely the gap left between the adult females of *A. major* and adults of *A. rufa.* The evidence of this is found not only in the occipital region, in the lesser development of the various crests and processes, and in the post-zygomatic notch, but in the size and shape of the zygomatic arches and the vacuities which they enclose; in the length and shape of the nasals; in the length and ratios of the fronto-parietal line and of the premaxillaries; in the position of the antorbital foramina, in the ratio of the upper molar series to the basilar-length—in fact in all the characters which serve to distinguish the adults of the two species.

The growth of the teeth in A. *major* has not kept pace with that of the skull. They were doubtless large enough in *A. rufa* to subserve the wants of the animal; and since the increase in size which the California species has undergone has not been accompanied by change in food-habits, a corresponding enlargement of the teeth has not been necessary. Conversely, while the grinding apparatus remains the same in both, the machinery by which it is worked has come to be largely increased in size and power.

From the foregoing study of the development of the skull in the present species, it appears that *Aplodontia major* was derived from *A. rufa* or its immediate predecessors, and that it is the most highly differentiated form yet known of the remarkable, primitive Haplodont type of the Sciuromorph series.

	APLODONTIA RUFA.							
	U. S. NATIONAL MUSEUM.							Mus. CHM
2103	22205	3942	3891	22203	22204	22146	2476	1130
♂ im.	♂ ad.	♂ ad.	♂ ad.	im.	im.			♂ im.
61.00	65.60	64.00	63.00	59.70	60.30	63.00	....	59.60
56.70	61.60	60.50	59.70	56.30	56.70	58.50	....	55.00
66 00	71.00	....	67.00	62.50	61.30	....	....	66.50
51.00	55.20	56.80	55.00	51.40	50.70	....	....	50.60
35.00	37.00	36.90	34.70	33.30	35.20	34.70	....	33.90
47.80	53.00	....	....	47.00	49.80	51.30	....	46.70
11.20	10.00	9.90	8.80	11.40	9.80	....	11.70	10.30
24.30	28.00	28.40	23.80	21.30	22.60	25.50	26.40	25.00
11.00	11.90	13.00	11.10	11.30	11.40	11.10	11.90	10.00
4.00	7.00	6.80	5.60	4.70	4.80	5.70	7.50	4.00
15.00	17.00	17.00	15.30	16.80	16.00	15.50	15.50	15.60
10.30	11.30	12.80	11.50	10.50	10.00	11.00	11.10	11.00
18.60	21.00	20.20	21.50	19.50	19.50	20.80	18.80	19.00
37.80	40.60	41.40	41.00	38.60	37.70	40.00	39.30	37.70
17.30	17.50	18.30	17.70	17.00	15.80	17.30	17.80	17.20
15.70	16.40	17.70	16.40	16.30	14.80	16.50	17.20	16.10
5.90	5.40	4.60	5.60	5.70	5.40	5.80	4.80	5.60
6.50	6.00	5.70	6.30	6.30	6.10	6.40	6.20	6.20
5.40	4.30	4.30	....	4.80	4.40	....	....	4.50
19.00	21.00	19.40	18.50	17.50	18.80	18.70	....	17.40
21.00	23.70	....	....	21.00	21.50	23.70	....	21.20
16.00	15.90	14.80	15.40	14.30	14.20	15.20	....	15.00
18.50	20.30	....	21.80	18.50	19.40	18.70	....	19.80
18.00	18.20	19.20	19.50	17.70	18.50	16.60	18.60	18.20
48.70	49.20	50.50	49.00	47.40	47.90	....	49.40	47.30
26.40	31.00	30.00	30.00	27.00	28.50	....	30.50	28.40
21.50	22.80	....	22.50	23.00	20.80	....	22.20	20.60
11.40	11.30	10.80	11.80	11.60	11.40	....	11.70	11.00
17.40	17.60	18.70	18.00	17.00	16.40	....	17.60	17.20
15.40	16.00	17.20	16.70	15.90	15.00	....	16.40	16.10
83.60	84.14	88.75	87.30	86.09	84.07	....	....	84.89
61.96	61.88	64.68	65.07	64.65	62.52	....	....	63.25
28.36	28.40	28.59	28.09	28.47	26.20	27.46	....	28.85
39.83	42.68	44.37	37.77	35.67	37.47	....	....	41.94
30.49	32.01	31.56	34.12	32.66	32.33	....	....	31.87
79.83	75.00	78.90	77.77	79.39	79.43	....	....	79.36
54.20	63.00	59.40	61.22	56.96	59.49	....	61.74	60.04
45.26	42.50	49.29	46.66	53.05	54.44	43.53	45.07	40.00
89.95	89.61	95.53	92.12	91.29	89.41	....	....	92.00
66.66	65.90	68.42	68.67	68.56	66.49	68.37	....	68.54
30.51	28.39	30.24	29.64	30.19	27.86	29.57	....	31.27
27.68	26.62	29.25	27.47	28.95	26.10	28.20	....	29.25
42.85	45.45	46.94	39.86	37.83	39.85	43.58	....	45.45
32.80	34.09	33.38	36.01	34.62	34.39	35.55	....	34.54
85.89	79.87	83.45	82.07	84.17	84.47	....	....	86.00
19.75	16.23	16.36	14.74	20.24	17.28	....	....	18.72
31.74	29.38	31.73	32.32	31.43	32.62	28.37	....	33.09

TABLE OF CRANIAL MEASUREMENTS

(ALL MEASUREMENTS IN MILLIMETERS.)

	APLODONTIA MAJOR.								APLODONTIA RUFA.							
	MUSEUM OF C. HART MERRIAM.								U. S. NATIONAL MUSEUM.							Mus. CHM
	2106	2101	2108	2107	2102	2105	2104	2103	22205	3942	3891	22203	22204	22146	2476	1130
	♂ ad.	♂ ad.	♀ ad.	♀ ad.	♀ ad.	♂ im.	♀ im.	♂ im.	♂ ad.	♂ ad.	♂ ad.	im.	im.			♂ im.
Basilar-length (from one of the occipital condyles to the posterior edge of alveola of incisor of same side)	68.70	69.00	67.30	67.40	65.00	63.20	63.00	61.00	65.60	64.00	63.00	59.70	60.30	63.00	....	59.60
Basilar-length of Hensel (from inferior lip of foramen magnum to posterior edge of alveola of incisor)	64.70	64.20	63.30	62.20	61.00	59.40	58.00	56.70	61.60	60.50	59.70	56.30	56.70	58.50	....	55.00
Occipito-nasal length (from occipital crest in median line to most anterior point of nasals)	75.70	74.60	73.20	72.40	70.50	69.50	70.00	66 00	71.00	....	67.00	62.50	61.30	....	....	66.50
Greatest zygomatic breadth	62.30	62.40	57.00	61.20	55.80	52.70	53.90	51.00	55.20	56.80	55.00	51.40	50.70	....	....	50.60
Least breadth of post-zygomatic notch	40.60	39.60	37.00	37.50	36.80	36.70	35.20	35.00	37.00	36.90	34.70	33.30	35.20	34.70	....	33.90
Greatest breadth across mastoids	59.70	61.00	54.20	58.20	53.60	50.30	50.40	47.80	53.00	....	....	47.00	49.80	51.30	....	46.70
Least breadth at interorbital constriction	11.30	10.40	10.00	10.40	10.70	11.60	10 90	11.20	10.00	9.90	8.80	11.40	9.80	....	11.70	10.30
Greatest length of nasal bones	28.80	27.60	26.60	26.50	27.40	25.70	25.70	24.30	28.00	28.40	23.80	21.30	22.60	25.50	26.40	25.00
" width " " anteriorly	12.60	13.10	12.00	11.80	12 00	11.00	10.50	11.00	11.90	13.00	11.10	11.30	11.40	11.10	11.90	10.00
Least " " " posteriorly	7.00	7.00	6.30	6.40	6.00	6.00	6.00	4.00	7.00	6.80	5.60	4.70	4.80	5.70	7.50	4.00
" " of rostrum in front of zygomæ	17.60	17.20	17.70	15.80	16.20	15.50	15.30	15.00	17.00	17.00	15.30	16.80	16.00	15.50	15.50	15.60
Distance between outer rims of alveolæ of upper incisors	13.40	12.80	13.00	11.90	12 00	11.60	11.00	10.30	11.30	12.80	11.50	10.50	10.00	11.00	11.10	11.00
" from posterior rim of alveola of incisor to anterior rim of alveola of 2d upper premolar	22.50	22.10	21.40	21.00	21.30	19.50	19.40	18.60	21.00	20.20	21.50	19.50	19.50	20.80	18.80	19.00
" " " " " " " " " post palatal notch ('palatal length')	43.30	43.20	42.80	42.00	41.80	39.50	39.80	37.80	40.60	41.40	41.00	38.60	37.70	40.00	39.30	37.70
Length of upper molar series measured on the alveolæ	18.00	18.50	18.70	18.60	17.80	17.50	18.40	17.30	17.50	18.30	17.70	17.00	15.80	17.30	17.80	17.20
" " " " " " " " crowns	17.00	17.80	18.00	....	16.70	15.80	17.00	15.70	16.40	17.70	16.40	16.30	14.80	16.50	17.20	16.10
Distance between alveolæ of upper molar series anteriorly	6.00	6 60	6.20	6.20	6.40	5.90	6.80	5.90	5.40	4.60	5.60	5.70	5.40	5.80	4.80	5.60
" " " " " " " posteriorly	6.60	6.80	6.80	6.60	5.80	6 10	6.80	6.50	6.00	5.70	6.30	6.30	6.10	6.40	6.20	6.20
Width of pterygoid fossa at base	5.00	5.00	4.20	5.20	4 50	5.30	5.30	5.40	4.30	4.30	....	4.80	4.40	....	....	4.50
Apex of post-palatal notch to foramen magnum	21.00	20.60	20.00	20.00	19.30	19.70	18.70	19.00	21.00	19.40	18.50	17.50	18.80	18.70	....	17.40
Greatest length (transverse) of auditial bullæ	26.00	25.70	24.50	25.00	23.90	22.20	23.00	21.00	23.70	....	....	21.00	21.50	23.70	....	21.20
Distance between outer borders of occipital condyles	17.30	17.30	16.00	16.60	16.00	16.40	15.80	16.00	15.90	14.80	15.40	14.30	14.20	15.20	....	15.00
Height of occipital crest from inferior lip of foramen magnum	23.50	21.30	22.60	20.50	20.70	19.80	19.10	18.50	20.30	....	21.80	18.50	19.40	18.70	....	19.80
Fronto-palatal depth (taken at middle of molar series	21.00	20.50	20.50	19.70	19.80	19.80	18.80	18.00	18.20	19.20	19.50	17.70	18.59	16.60	18.60	18.20
Greatest length of single mandible (exclusive of incisors)	54.70	54.40	53.80	53.60	53.00	50.60	51.70	48 70	49.20	50.50	49.00	47.40	47.90	....	49.40	47.30
Height of coronoid process from angle	34.60	32.80	32.30	32.70	32.00	30.00	30.00	26.40	31.00	30.00	30.00	27.00	28.50	....	30.50	28.40
Breadth of flattened transverse plate of angle	27.00	25.30	25.70	25.00	24.60	22.50	23.60	21.50	22.80	....	22.50	23.00	20.80	....	22.20	20.60
Distance from incisors to 1st premolar (on alveolæ)	13.80	13.60	12.30	13.00	13.00	11.80	12.00	11.40	11.30	10.80	11.80	11.60	11.40	....	11.70	11.00
Length of under molariform series measured on the alveolæ	18.20	18.50	18.50	18.50	18.10	17.60	18.50	17.40	17.60	18.70	18.00	17.00	16.40	....	17.60	17.20
" " " " " " " " crowns	16.80	17.20	17.30	17.30	16.60	15.70	16.50	15.40	16.00	17.20	16.70	15.90	15.00	....	16.40	16.10
Ratio of zygomatic breadth to basilar-length	90.68	90.43	84.60	90.80	85.84	83.38	85.55	83.60	84.14	88.75	87.30	86.09	84.07	....	....	84.89
" " palatal length " "	63.02	62.60	63.59	62.31	64 30	62.50	63.17	61.96	61.88	64.68	65.07	64.65	62.52	....	....	63.25
" " upper molariform series (alveolæ) to basilar-length	26.20	26.81	27.78	27.59	27.38	27.68	29.20	28.36	28.40	28.59	28.09	28.47	26.20	27.46	....	28.85
" " length of nasals " "	41.42	40.00	39.52	37:83	42.15	40.65	40.79	39.83	42.68	44.37	37.77	35.67	37.47	....	....	41.94
" " muzzle (incisors to 1st pm.) " "	32.75	32.02	31.79	31.15	32.76	30.85	30.79	30.49	32.01	31.56	34.12	32.66	32.33	....	....	31.87
" " length of mandible " "	79.62	78.84	79.94	79.52	81.53	80.06	82.06	79.83	75.00	78.90	77.77	79.39	79.43	....	....	79.36
" " height of coronoid (from angle) to length of mandible	63.25	60.29	60.14	61.00	63.77	59.28	58.02	54.20	63.00	59.40	61.22	56.96	59.49	....	61.74	60.04
" " greatest breadth of nasals to length of same	43.75	47.46	45.11	44.52	43.75	42.80	40.85	45.26	42.50	49.29	46.66	53.05	54.44	43.53	45.07	40.00
" " zygomatic breadth to basilar-length of Hensel	90.63	90.72	90.00	98.39	91.47	88.72	92.93	89.95	89.61	95.53	92.12	91.29	89.41	....	....	92.00
" " palatal length " " " "	60.69	67.28	67.63	67.52	68.52	66.49	68.62	66.66	65.90	68.42	68.67	68.56	66.49	68.37	....	68.51
" " upper molariform series (alveolæ) to basilar-length of Hensel	27.66	28.81	29.54	29.90	29.18	29.46	31.72	30.51	28.39	30.24	29.64	30.19	27.86	29.57	....	31.27
" " " " " (crowns) " " "	26.27	27.72	28.42	....	27.37	26.59	29.31	27.68	26.62	29.25	27.47	28.95	26.10	28.20	....	29.25
" " length of nasals " " "	44.50	42.99	42.02	42.60	44.91	43.26	44.25	42.85	45.45	46.94	39.86	37.83	39.85	43.58	....	45.45
" " muzzle (incisors to 1st pm.) " " "	34.77	34.42	33.80	33.76	34.91	32.82	33.44	32.80	34.09	33.38	36.01	34.62	34.39	35.55	....	34.54
" " length of mandible " " "	85.54	84.73	84.99	86.17	86.88	85.18	89.13	85.89	79.87	83.45	82.07	84.17	84.47	....	....	86.00
" " interorbital constriction " " "	17.46	16.19	15.79	16.72	17.54	19.52	18.79	19.75	16.23	16.36	14.74	20.24	17.28	....	....	18.72
" " fronto-palatal depth " " "	32.45	31 93	32.38	31.67	32.45	33.33	32.41	31.74	29.38	31.73	32.32	31.43	32.62	28.37	....	33.09

XVIII.—*The Meteorite from Glorieta Mountain, Santa Fé Co., New Mexico.*

BY GEORGE F. KUNZ.

Read Nov. 30, 1885.

On August 9th, 1884, three large masses of meteoric iron were found by Mr. Charles Sponsler, on the ranch of Mrs. Roival, near Canonçito, Santa Fé Co., New Mexico, five miles from the summit of Glorieta Mountain, and three and a half from Glorieta Post Office. Mr. Sponsler, who was prospecting at the time, supposed that he had stumbled upon a mineral of some value, but as yet I have had no word from him, and for the exact information I am indebted to Mr. J. H. Bullock, who, during the month of August, 1885, thoroughly examined and dug over the ground, working about six weeks steadily, and was rewarded by securing three more masses. In the meanwhile, a Mexican had also found a small piece, making seven fragments thus far obtained. This latter piece disappeared with the Mexican before I could secure it.

No. 1 weighs 148½ lbs. (67.35 kilos). About one-third of the whole surface shows the disjuncture very plainly, as also the exact point where this began. The mass measures 15½ inches (39 cm.) in length, 12 inches (30 cm.) in width, and 8¾ inches (22 cm.) at the thickest part, and at the thinner 5 inches (12 cm.). One portion has a peculiar bubbled pasty appearance, as if the mass had been cooled in water at this point. Some of the depressions on the surface, or pittings, are 5 cm. across, and quite deep and well-marked. The upper figure on plate XXIII represents the torn side of this mass. Plate XXVI shows the Widmannstätten figures produced by etching a surface of an entire cut from No. 1; this plate is printed from an electrotype taken directly from the etched slab.

No. 2 weighs 115 lbs. (52.38 kilos.), and measures 16½ inches

(41 cm.) in length, 10 inches (24 cm.) in width, and 6½ inches (16 cm.) in thickness. About one-third of the surface of this piece shows the remarkable rupture, the remainder being covered with the pittings. On one corner there is a portion, 10 inches by 6, which is evidently the spot where the mass struck the rock. Here the pittings are flattened and the whole mass distorted and curled over, giving it a radiated or fan-like appearance. The front, or pitted, side of No. 2 is well exhibited in Plate XXI, and the torn side in Plate XXIII, lower figure plate.

No. 3 weighs 53½ lbs. (24.263 kilos.), and measures 12 inches (30 cm.) in length, 8½ inches (21¼ cm.) in height, and 6 inches (15 cm.) in thickness in the thickest part. Over five-sixths of the entire surface is pitted, some of the depressions being 5 cm. across and nearly 2 cm. deep. The place of rupture is plain, and the iron here is coarsely fibrous, possibly because it was farther from the point of impact. There is also a fissure about 4 inches (10 cm.) deep and nearly 1 cm. wide, opposite the broken face. In this fissure are two ends of chisels which were broken in the attempt to pry off this piece, and which may have enlarged the opening. The front side of No. 3 is shown in Plate XXII.

All the new masses are as follows:

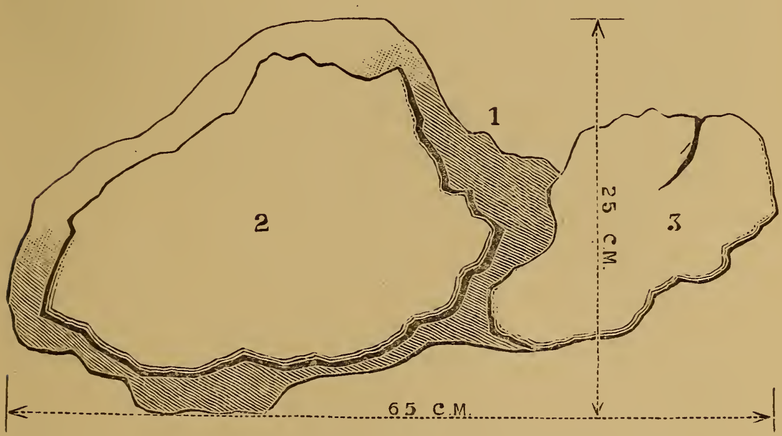
No. 4 weighs 1.204 kilos (2.65 lbs.). One-third of the surface shows the disruption, as in No. 2, the other parts being unaffected and showing the crust surface, Plate XXV. The broken surface is partially drawn out toward the part that was broken off from it, and one edge shows a fracture suggesting cleavage. It is 50 mm. high, 125 mm. long, and 50 mm. wide, or about 2 by 5 by 2 inches. One of the pittings which has been increased in size by the disruption measures 60 mm. in length, 25 mm. in width, and 15 mm. in breadth. (See Plate XXIV.)

No. 5 weighs 1.126 kilos (2.48 lbs.), measures 100 mm. in length, 75 mm. in width, and 48 mm. in height, about 4 by 3 by 2 inches. Five-sixths of the entire surface bears marks of the violent disruption, Plate XXIV, and is undoubtedly from the upper corner, between Nos. 1 and 3. A raised octahedral structure is revealed on two-thirds of its surface, and the pitted side shows evidence of having received a part of the blow, Plate XXV.

No. 6 weighs 1.05 kilos (2.31 lbs.), measures 125 mm. in length, 82 mm. in width, and 45 mm. in thickness at the thickest part, or about 5 by $3\frac{1}{4}$ by $1\frac{3}{4}$ inches. It is quite flat, the fracture having left a flat surface suggestive of a cleavage. Altogether this mass closely resembles No. 4. (See Plates XXIV and XXV.)

When the meteorite struck the rock, all these pieces flew asunder; the $148\frac{1}{2}$ lb. piece was found eight feet from the 115 lb. and $53\frac{1}{2}$ lb. pieces, a *fact which shows conclusively that the meteorite did not burst in mid-air.* The small pieces picked up by Bullock and the Mexican were 45 and 50 feet from the large masses, having been hurled further because of their comparative lightness. They were all buried in the vegetable mould covering the rock in places, the larger pieces to the depth of ten inches, but some of the smaller fragments were buried only about three inches.

The accompanying diagram will give a general idea of the relative position of the three pieces:



No. 1 projecting above and below No. 2, as indicated by the shading, and No. 3 fitting in at the lower right hand end. The other four pieces evidently fitted in between the upper end of No. 3 and No. 1. The dimensions of the whole were approximately as follows: length 25 inches (65 cm.), height 10 inches (25 cm.), thickness 15 inches (37 cm.). It is curious that so large and compact a mass of iron should have been so completely broken asunder, and in this respect the fall is quite unique. The fractures are very clean considering the size of the fragments, although the edges are somewhat irregular. No. 1 is filled with elongated hollows, proving that it was disturbed, and the twistings in No. 2 at the point of impact would lead to the conclusion that the falling body was partly semiplastic; but Prof. R. H. Thurston, who kindly examined the iron, compares the fracture to the effect that is produced by a sudden heavy blow on cold iron, and has observed the same violent wrenching in an iron target used in heavy gunning practice and now at the Stevens Institute, Hoboken, N. J.

In order to separate these large pieces, the force of the blow must have been enormous, for the disrupted surface is over one foot square, and the material as tough as any meteoric iron yet found. That the impact was on a rock may well be proven by the fact that the smaller pieces were torn off as readily as the larger ones. The iron has few signs of weathering, and hence fell recently. It is not deliquescent, and hence contains no chlorine. A red, ochreous, coating from the soil in which it was imbedded, not removable by washing, is a distinguishing characteristic of all the pieces of this iron.

The following is the result of an analysis of a compact piece of iron from No. 3, made by Mr. James B. Mackintosh, E. M., of the School of Mines, New York City :

Fe	87.93
Ni	11.15
Co	0.33
P	0.36
	99.77

Carbon, sulphur, and other constituents were not determined. The specific gravity of mass No. 2 was taken on a common steelyard, and found to be 7.66+. The figures may be of interest as showing the homogeneity of the mass, although the method employed was not delicate.

This iron is one of the Holosiderites of Daubrée, and comes under the general group of Caillite of Stanislaus Meunier ; it is related to the irons of Augusta County, Virginia; Whitfield County, Georgia, and Washington County, Wisconsin. It is of characteristic octahedral structure, and the Widmanstätten figures are made up of kamacite (Balkeneisen or beam-iron), *i. e.*, iron with little nickel, enveloped in taenite (Bandeisen), *i. e.*, iron rich in nickel, and plessite (Fülleisen). On the single cut made, one field of dark plessite measured 17 by 8 mm., the kamacite from 5 to 2 mm. in breadth. The taenite was abundant and brilliant. This is perhaps one of the most beautiful etching irons ever found, as the print from the large section will show. (Folding Plate XXVI.) Nearly all the large mass has been cut into slices, and the iron is seen to be very homogeneous throughout, with the exception of an occasional space measuring 1 to 4 mm. across. One of these spaces, near the centre of the mass, was evidently formed by the shock of disruption. In a few instances this explanation is verified by a palpable curving of the Widmanstätten figures, showing that nearly every part of the thick mass was twisted and wrenched, when it burst with such tremendous force. The ruptures on Nos. 1 and 3 show large patches of troilite. In cutting No. 1 large streaks of this metal and schreibersite were observed, the largest of which was 10 cm. long and 4 mm. wide. Two of the streaks, 10 cm. apart, ran parallel to each other in peculiar crescent like shapes.

Olivine was observed at the upper end of No. 1, a surface about 10 cm. square being completely filled with it. The color in some instances was brownish-golden, or rich yellow, and as plentiful as in the "Pallas Iron." The largest grains observed measured from 8 to 14 mm., *and some of these pieces yielded perfect gems over 4 mm. in width.*

I was kindly informed by Dr. Whitman Cross, of Denver, Col., that on Oct. 6th, 1884, a meteorite was presented to the Colorado Scientific Society, with descriptive remarks, by Mr. Richard Pearce, of the Boston and Colorado Silver Mining Company. It was sent to the Company from Albuquerque, New Mexico, as silver bullion, and could not be traced further back, although it was probably found in the vicinity of the place from which it was forwarded. Its weight, before cutting, was about 2.5 kilograms, and its dimensions were 45x80x100 mm.

A short paper upon this meteorite was read before the Colorado Scientific Society, on June 1st, 1885, by Mr. L. G. Eakins, of the Geological Survey, containing an analysis of the iron, which is subjoined :

Fe	88.760*	Mn	trace
Ni	9.860	C	0.410
Co	0.510	P	0.182
Cu	0.034	S	0.012
Zn	0.030	Si	0.044
Cr	trace		
			99.842

This paper by Mr. Eakins appears in the Proc. of the C. S. S. for 1885, and these figures were kindly furnished by him.

The similarity between this analysis and that of the Glorieta meteorite leads me to believe that the Colorado iron is the seventh fragment, which was found by the Mexican, and that he mistook it for silver bullion and disposed of it as such.

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* Mean of 88.66, 88.77 and 88.84.

Explanation of Plates.

Plate XXI. Front or pitted side of piece No. 2. Two-fifths natural diameter.

Plate XXII. Same of No. 3. Four-ninths nat. diam.

Plate XXIII. Upper figure; torn side of No. 1.
Lower figure; same of No. 2. Both one-third nat. diam.

Plate XXIV. Torn surfaces, Nos. 4, 5 and 6.

Plate XXV. Crust surfaces of the same. All seven-tenths nat. diam.

Plate XXVI. Etched surface of a cut from No. 1, natural size.

A scale of inches was photographed with the specimens shown on Plates XXI, XXII and XXIII, and appears therefore, correspondingly reduced.

XIX.—*Notes on a Collection of Fishes from the Monongahela River.*

BY BARTON W. EVERMANN AND CHARLES H. BOLLMAN.

Read April 12, 1886.

During July and August, 1885, Mr. Bollman made a small collection of fishes in the Monongahela River and a few small creeks flowing into it. The bulk of the collection was made in the Monongahela at Monongahela City, at Lock Number Nine, on that river, near where it enters the State of Pennsylvania from West Virginia, and in a little stream called Pigeon Creek, which flows into the river near Monongahela City. As the collecting was done with a small twelve-foot seine, the smaller or more common shallow-water species constitute the chief part of the collection.

The common names given are those in local use. The numbers in parentheses refer to Dr. Jordan's Catalogue of North American Fishes.* All the specimens of this collection are now in the museum of the Indiana University, Bloomington, Ind.

1. Lepisosteus osseus (Linnæus). (107.)

    Gar Pike.

    Abundant at Lock No. 9.

2. Noturus flavus Rafinesque. (119.)

    Found to be common in Pigeon Creek.

3. Ictalurus punctatus (Rafinesque). (134.)

    Channel Cat.

    One specimen taken at Lock No. 9 ; very common in the river at Monongahela City.

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* A Catalogue of the Fishes known to inhabit the waters of North America, North of the Tropic of Cancer, with notes on the species discovered in 1883 and 1884. By David Starr Jordan, Washington.

4. Ictalurus furcatus (Cuvier & Valenciennes). (135.)
Two specimens secured at Lock No. 9.

5. Ictiobus velifer (Rafinesque). (148.)
Carp Sucker.
One seen at Lock No. 9 ; common at Monongahela City.

6. Catostomus teres (Mitchill). (170.)
Common Sucker.
Common in Pigeon Creek.

7. Catostomus nigricans Le Sueur. (171.)
"Mullet ;" Stone-Roller.
Abundant at all places visited.

8. Moxostoma macrolepidotum (Le Sueur). (185.)
White Sucker.
Very common everywhere.

9. Campostoma anomalum (Rafinesque). (219.)
Rather common in Pigeon Creek ; a few taken in the river at Lock No. 9.

10. Pimephales notatus (Rafinesque). (219.)
Taken from the river at Monongahela City ; not common.

11. Cliola vigilax Baird & Girard. (223.)
Abundant at all places seined.

12. Notropis deliciosus stramineus (Cope). (233b.)
Only one specimen taken.

13. Notropis hudsonius (Clinton). (246, 246b.)

Clupea hudsonia Clinton, Ann. Lyc. Nat. Hist., N. Y., I, 49, pl. 2, fig. 2, 1824 (Hudson River).

Leuciscus hudsonius DeKay, Nat. Hist. N. Y., 206, pl. 34, fig. 109, 1842 (Hudson River). Agassiz, Lake Superior, 372, 1850, (Lakes Superior and Huron). Storer, Synopsis Fish., 409, 1845. Günther, Cat. Fish., VII, 251, 1868.

Hybopsis hudsonius Cope, Proc. Acad. Nat. Sci. Phila., 1864, 279 (Michigan). Cope, Cypr. Penn., 386, 1866 (Delaware River). Abbott, Am. Naturalist, VIII, 1874, 332 (Delaware River). Nelson, Bull. Ill. Mus. Nat. Hist., I, 46, 1876. Forbes, Bull. Ill. Lab. Nat. Hist., 82, 1883. Uhler and Lugger, Fishes Md., 149, 1876 (Patapsco River).

Alburnops hudsonius Jordan, Cat. Fresh Water Fish N. A., 419, 1878. Jordan, Ann. N. Y. Acad. Sci., 1877, I, 109 (Delaware River). Jordan, Bull. Ill. Mus. Nat. Hist., II, 56, 1878. Jordan, Man. Vert.. 290, 1880.

Cliola hudsonia Jordan & Gilbert, Synopsis, 171, 1883.

Notropis hudsonius Forbes, Rept. Ill. Fish Comm., 1884, 77. Cragin, Bull. Washburn Coll. Lab. Nat. Hist., I, 108, 1885 (Wild Cat Creek). Jordan, Cat. Fish. N. A., 24, 1885.

Hybopsis storerianus Cope, Proc. Acad. Nat. Sci. Phil., 1864, 299 (Michigan). Cope, Cypr. Penn., 386, 1866 (Delaware and Potomac Rivers). Jordan, Geol. Rept. Ind., 1874. Nelson, Bull. Ill. Mus. Nat. Hist., I, 46, 1876.

Leuciscus storerianus Günther, Cat. Fish., VII, 250, 1868 (Susquehanna River).

Alburnops storerianus Jordan, Cat. Fresh Water Fish. N. A., 419, 1878.

Hudsonius storerianus Jordan, Man. Vert., 290, 1880.

Cliola storeriana Jordan & Gilbert, Synopsis, 171, 1883.

Hudsonius fluviatilis Girard, Proc. Acad. Nat. Sci. Phila., 1856, 200 (Chicago). Jordan, Man. Vert., 290, 1880.

Hudsonius amarus Girard, Proc. Acad. Nat. Sci. Phila., 1856, 200 (Potomac River).

Hybopsis amarus Cope, Fresh Water Fish. N. C., 460, 1877 (Catawba River).

Alburnops amarus Jordan, Ann. N. Y. Acad. Sci., 1877, I, 109 (Ocmulgee River). Jordan, Cat. Fresh Water Fish. N. A., 419, 1878.

Notropis hudsonius amarus Jordan, Cat. Fish. N. A., 24, 1885.

Hybopsis phaënna Cope, Proc. Acad. Nat. Sci. Phila., 1864, 279 (Delaware River). Abbott, Am. Naturalist, VIII, 1874, 333 (Delaware River).

Alburnops saludanus Jordan & Brayton, Bull. U. S. Nat. Mus., XII, 16, 1878 (Saluda and Catawba Rivers). Jordan, Cat. Fresh Water Fish. N. A., 419, 1878 (Santee Basin).

Cliola saludana Jordan & Gilbert, Synopsis, 170, 1883 (Santee Basin).

Luxilus selene Jordan, Bull. U. S. Nat. Mus., X, 60, 1877 (Bayfield, Wis.). Jordan Ann. N. Y. Acad. Sci., 1877, I, 110, (Lake Superior). Jordan, Man. Vert , 293, 1880.

Minnilus selene Jordan & Gilbert, Synopsis, 188, 1883 (Lake Superior).

Hudsonius euryopa Bean, Proc. U. S. Nat. Mus. 1879, 285 (McBean Creek, Ga.).

Cliola euryopa Jordan & Gilbert, Synopsis, 171, 1883 (Savannah River).

Habitat.—Great Lakes east and southward to Georgia and Alabama. Lakes Superior, Michigan and Huron; Hudson River; Delaware River; Susquehanna River; Patapsco River; Potomac River; Catawba River; Ocmulgee River; Saluda River; McBean Creek, Ga.; Savannah River; Kankakee River; Manhattan, Kans.

We have compared specimens of *hudsonius* and the supposed *amarus* from different localities and believe them to be identical. An examination of the teeth of a number of specimens shows that the difference, 1, 4–4, 0 or 1, and 2, 4–4 2 or 1, is too variable to be considered a reliable character. The caudal spot, prominent in the young, is most persistent in those specimens from sluggish and reedy streams, and we are convinced that this and other color characters depend simply upon the nature of the streams which the particular individuals inhabit.

We have examined numerous specimens from the following localities: Potomac River, U. S. Fish Comm. Carp Ponds, Kankakee River, Lake Michigan, Manhattan, Kans., and the Monongahela.

In this connection we wish to say that an examination of considerable material leads us to agree with Profs. Jordan and Gilbert in making *Ceratichthys lucens* equal to *Rutilus storerianus* Kirtland. Among the specimens examined, is one which was collected by Prof. Baird and Dr. Kirtland in Yellow Creek, Ohio, in August, 1853. In this specimen, the barbel is very evident. The synonymy of these species has been greatly confused heretofore, and it is with the hope of clearing up the confusion as much as possible that we have given the synonymy of *N. hudsonius* so far as we have been able to determine it.

14. Notropis whipplei (Girard). (261.)
 Very common at all places seined.

15. Notropis megalops (Rafinesque). (273.)
 Silverside.
 Very common everywhere.

16. Notropis jejunus (Forbes). (288.)
 But two specimens from Lock No. 9. These we have compared with Forbes's type and find them identical.

17. Notropis atherinoides Rafinesque. (308.)
 Two specimens.

18. Notropis rubifrons (Cope). (310.)
 The collection contains but two specimens, which are from Pigeon Creek.

19. Ericymba buccata Cope. (314.)
 Three specimens in the collection.

20. Rhinichthys atronasus (Mitchill). (321.)
 A single specimen from Pigeon Creek. Others were seen, however.

21. Hybopsis storerianus (Kirtland). (330.)
 Abundant in the river. There is little doubt that this species equals *Ceratichthys lucens* Jordan.

22. Semotilus atromaculatus (Mitchill). (347.)
 Chub.
 Very abundant in Pigeon Creek.

23. Dorosoma cepedianum (Le Sueur). (455.)
 Abundant in the river.

24. Percopsis guttatus Agassiz. (532.)
 Very common in the river.

25. Pomoxis annularis Rafinesque. (842.)
 Calico Bass.
 Very common.

26. Pomoxis sparoides (Lacépède). (843.)
 Calico Bass.
 Found in about equal numbers with the preceding.

27. Ambloplites rupestris (Rafinesque). (845.)
 Red-eye; Goggle-eye.
 Abundant in the creek, less so in the river.

28. Micropterus dolomiei (Lacépède). (877.)
 Small-mouthed Black Bass.
 Abundant in the river.

29. Etheostoma pellucidum Baird. (880.)
 Common everywhere in suitable places.

30. Etheostoma nigrum Rafinesque. (885d.)
 One of the most abundant darters of the locality.

31. Etheostoma blennioides Rafinesque. (894.)
 Not very common.

32. Etheostoma caprodes Rafinesque. (899.)
 Very common, especially at Lock No. 9.

33. Etheostoma phoxocephalum Nelson. (901.)
 The collection contains four specimens, all from Lock No. 9.

34. Etheostoma variatum Kirtland. (912.)

Little, if anything, was known of this interesting darter since

1840, when it was first described by Dr. Kirtland, until recently. Two specimens were obtained April 25, 1885, by Mr. Amos W. Butler, at Brookville, Indiana; and a day later, Prof. Charles H. Gilbert obtained a specimen from lower down in the same river, —the Whitewater. The collection made by Mr. Bollman contains a single specimen which he obtained from the Monongahela, about one-half mile below Lock No. 9. This specimen is $1\frac{7}{8}$ inches in length, and does not differ materially from the Brookville specimens. A full description of the Brookville specimens was published by Dr. Jordan in the Proceedings of the United States National Museum for 1885, pp. 163–165.

35. ETHEOSTOMA ZONALE (Cope).) (916.)
Zoned Darter.
But one specimen of this darter was obtained.

36. ETHEOSTOMA FLABELLARE Rafinesque. (923.)
Fan-tail Darter.
Very abundant everywhere.

37. ETHEOSTOMA CŒRULEUM Storer. (936.)
Rainbow Darter.
Perhaps the most abundant darter in the Monongahela.

38. STIZOSTEDION VITREUM (Mitchell). (948.)
Yellow Pike.
Only one specimen taken in the river at Monongahela City.

39. APLODINOTUS GRUNNIENS Rafinesque. (1083.)
White Perch.
This species was abundant in the river.

40. COTTUS RICHARDSONI Agassiz. (1320.)
Miller's Thumb.
Not very common; two or three specimens were obtained at Lock No. 9.

INDIANA UNIVERSITY,
March 15, 1886.

XX.—*On the Geology of Long Island.*

BY F. J. H. MERRILL.

Read November 7, 1884.

The following contributions to the Geology of Long Island are the result of some five weeks' exploration and study of that well-known and interesting region, during the summer of 1883. This paper is but preliminary; and many questions which have been merely touched upon or wholly neglected, the writer hopes to discuss at length when more extended research and deeper excavations have given him further data.

The surface geology of this region has already been minutely described by Mather in his Report on the Geology of the First District of New York, 1843, and also, with special reference to the glacial deposits, by Mr. Warren Upham, in his articles on "Terminal Moraines of the North American Ice Sheet," Am. Jour. Sci., III, 18. I shall therefore review very briefly the physical characteristics of the island and endeavor to throw what additional light I can upon its geological history, from the study of sections of strata recently exposed, and such other phenomena as it has been my fortune to observe.

Long Island as a whole is comparatively low and flat, but throughout the central part is a range of hills extending from Bay Ridge northeasterly to Roslyn, and thence continuing to Montauk Point in a series of elevations, the more important of which are known as West, Dix, Comac, Bald, and Shinnecock Hills. The average height of this chain is about 250 feet; but at some points it is much greater. Harbor Hill at Roslyn is 384 feet above tide; Jane's Hill is 383 feet high; Reuland's Hill has an elevation of 340 feet, and Wheatly Hill is 369 feet above the sea.

There is also, along the north shore, an elevation which usually follows the contour of the numerous deep bays and inlets, varying in hight from 30 to 200 feet, and almost continuous from

Astoria to Orient Point. These two ranges of hills are the result of glacial action, and the more southern chain marks the southern limit of the drift.

Upham and others, in speaking of these ranges, have called them moraines. If the word moraine is to be thus used, and present custom in the United States appears to sanction the use, it must be taken in a different sense from that accorded to it in most regions of glacial action. In Switzerland and other mountainous countries, the term is applied to great accumulations of boulders and rock detritus, piled up along the sides or front of a glacier. Throughout most of Long Island and at many points on the New England coast, however, the thickness of the drift on the ridges marking the southern limit of glacial extension is very slight and in some cases it is wanting. In these cases, the term moraine would be synonymous with the southern limit of the continental glacier.

South of the backbone, as the central range of hills is called, the surface is nearly level, gently sloping southward in an unbroken gravelly plain ; while between this ridge and the north shore is a second plain with an elevation of 50 to 100 feet, and especially noticeable between Port Jefferson and Riverhead. From many of the deep bays on the north shore, valleys extend through the hills in a southerly direction. These depressions, thirty in number between East New York and Riverhead, have been explored by Mr. Elias Lewis, Jr., of the Long Island Historical Society.* He finds them to average about 25 feet in depth and to be occupied usually by small streams most of which flow southward. These valleys are evidently the beds of rivers formed by the melting of the ice sheet in the Champlain Period.

There are no important lakes or rivers now on Long Island, but there are numerous ponds of clear cool water, without visible inlet or outlet. The existence of these ponds depends on the fact that in the stratified sands of the island, which are underlain by clays, a uniform water-level, or plain, exists,† which rises northward from low-tide-level on the south shore at the rate of 12½ feet per mile. Wherever a basin has been excavated

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* Am. Jour. Sci., Series III, Vol. XIII.

† Dana, Manual of Geology, p. 664.

below the surface of this plain, it would necessarily be filled by these subterranean waters, which, by their constant percolation through the sand, would remain pure and clear, without material or sudden change of level under average conditions. The largest of these ponds is Lake Ronkonkoma, which is three miles in circumference, and has a maximum depth of 83 feet.

The coast-line of Long Island is strikingly irregular. Along the north shore are eight deep and extensive bays, which form excellent harbors, and also a large number of inlets, most of which are navigable. At the heads of these bays, numerous springs of pure water issue from the hillsides, indicating the presence of an impervious stratum within the hills. The east end of the island is penetrated by Great and Little Peconic Bays to a depth of 22 miles, while the south shore west of Southhampton for about 95 miles, consists of an intricate series of shallow creeks partly surrounded by salt marsh, tributary to Shinnecock, Moritches, Great South, Hempstead, and other bays, which are divided from the ocean by long sand beaches, or reefs intersected in places by narrow inlets. Shelter, Robbin's, Plum, Gull and Gardiner's Islands, which form part of Suffolk County, New York, do not differ from Long Island essentially in physical or geological characteristics.

The lithology of the island is comparatively simple, the crystalline rocks being confined to quite a limited area. The greater part of the region consists of gravel, sand and clay, overlain along the north shore and for some distance southward, by glacial drift. This material forms an important element of the surface formation, and though it has been already described by Mather and Upham, I shall devote a short space to its discussion. For the sake of clearness, we may describe the drift as of two kinds: 1st, the till or drift proper, a heterogeneous mixture of gravel, sand and clay, with boulders, and 2d, the gravel drift, a deposit of coarse yellow gravel and sand, brought to its present place by glacial and alluvial action, but existing near by in a stratified condition, before the arrival of the glacier. This yellow gravel drift, which in a comparatively unaltered condition forms the soil of the pine barrens of southern and eastern Long Island, and is exposed in section at Crossman's brickyard in Huntington, is equivalent to and indeed identical with the *yellow drift* or *preglacial drift* of New Jersey, a formation of very great extent in that State, and of which the origin and source have not yet been fully explained, though it is always overlain by the glacial drift proper where these formations occur together.

In the hills near Brooklyn the till attains its maximum depth. This has never been definitely ascertained, but is probably between 150 and 200 feet. The only information we have on the subject is from a boring in Calvary Cemetery, where the drift was 139 feet deep, and this point is nearly five miles north of Mt. Prospect, which is 194 feet high and probably consists for the most part of till. The occurrence of this till is quite local and very limited along the north shore between Roslyn and Horton's Point. From the former locality eastward the hills are mainly composed of stratified gravel and sand, probably underlain by clay. On the railroad between Syosset and Setauket, is an abundance of coarse gravel with but slight stratification. East of Setauket for some distance the drift is a fine yellowish sand which washes white on the surface, and at Wading River the drift with cobble-stones was only eighteen inches thick where exposed, being underlaid with fine yellow sand. Along the remainder of the north shore to Orient Point, 6 feet was the maximum depth of drift observed. Under this were stratified sands, gravels and clays, usually dipping slightly from the shore. On Brown's Hills, north of Orient, the drift is overlaid by 3 feet of fine micaceous sand, which has probably been carried to its present position by the wind. The drift at this locality is a clayey till, and its surface is strewn with an abundance of boulders of coarse red gneiss. On Shelter Island are high ridges of gravel overlain by a few feet of till. The hills from Sag Harbor eastward are also composed partially of unmodified drift, but the most extensive deposit on the east end of Long Island is between Nepeague Bay and Montauk Point. Here the drift is disposed in rounded hillocks from 80 to 200 feet above the sea, with bowl and trough-shaped depressions between. The bluffs along the south shore, which are rapidly yielding to the action of the waves, consist for the most part of boulder clay and hard-pan of considable depth, covered by a shallow layer of till. At a few places, however, on the south shore, west of the point, laminated blue clay streaked with limonite occurs, intercalated with the till. At the end of the point, a similar bed of clay is exposed, overlain by stratified sand. From the extremely limited character of the exposures, I am unable to determine whether the clay underlies the whole of the point or is merely local in its occurrence. In character and position, however, it is analogous to beds occurring on Block Island.

The boulders of Long Island attract the attention of the geologist by their size and variety. They represent almost every geological age; fossiliferous rocks of the Helderberg, Oriskany and Cauda Galli, Hamilton, Chemung and Eocene periods having been found in the drift. Examples of these are in the collection of the Long Island Historical Society. There are also various members of the Archæan series, viz., gneiss, granite, syenite, hornblende, chlorite, talcose and mica schist, limestone, dolomite, and serpentine; and the Palæozoic and Mesozoic ages are represented by Potsdam sandstone, Hudson River slate, Oneida conglomerate or Shawangunk grit, Catskill sandstone, and Triassic sandstone and trap. As the lithology of the boulders has been described in detail by Mather,* it would be superfluous for me to undertake a similar description.

In addition to the rocks mentioned above, a ferruginous sandstone and conglomerate occur abundantly in fragments along the east shore of Hempstead Harbor, and in the drift between Glen Cove and Oyster Bay. Many of these fragments contain vegetable impressions, but in only two localities have any leaf prints been found. These were West Island, Dosoris, and the well of the Williamsburg Gas Co. The prints are supposed to belong to Cretaceous plants, but the evidence is incomplete.

Many of the erratic blocks are of immense size, one in particular, of gneiss, on Shelter Island, near Jennings' Point, contained as a solid mass over 9000 cubic feet. It has split in three pieces since it was deposited. Mather† mentions a mass of granite near Plandome, which was estimated to contain 8000 cubic yards above the surface of the ground.

Having thus briefly reviewed the characters of the surface

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* Geol. 1st Dist. N. Y., pp. 165–177.

† Geol. 1st Dist., p. 174.

drift, we will now consider in detail the strata which underlie it. The crystalline rocks outcrop along the shore at Hellgate and over a limited area in the vicinity of Astoria. They consist of finely laminated gneiss and schists, tilted at a high angle, and belong to the same formation as the rocks of Manhattan Island. I am informed by Mr. Elias Lewis, Jr., that in boring an artesian well in Calvary Cemetery, near Brooklyn, a bed of gneiss was encountered at a depth of 182 feet. Further than this, we know nothing of the extent of the crystalline rocks on Long Island. The section obtained in the boring mentioned was as follows :

Surface loam and drift, - - -	139	feet.
Greenish earth, - - - - -	39	"
White clay with red streaks, - -	4	"
Gneiss, - - - - - -	400	"
Total, - -	582	feet.

The greenish earth referred to, lost its color on being treated with hydrochloric acid, and the white residue examined under the microscope appeared to consist of minute fragments of kaolinized feldspar, with occasional grains of quartz sand. The acid solution gave a strong reaction for iron, indicating a probable admixture of glauconite with the material. It is stated in Cozzens' Geol. Hist. of N. Y. Island, that a shell of *Exogyra costata*, with green-sand adhering, was found between Brooklyn and Flatlands, at a depth of 60 feet. This locality is about five miles south of the well just mentioned, and would indicate the presence of Cretaceous strata near Brooklyn.

The following data, also furnished by Mr. Lewis, of a well dug by the Nassau Gas Light Co., in Williamsburg, will give an idea of the formation at that locality :

Surface loam, - - - -	3	feet.	
Quick-sand (so called), - -	2	"	
Boulder clay, somewhat sandy, -	70	"	
Blue clay with pebbles. - -	27	"	
Oyster shells, - - - -			6 inches.
Total, -	102	feet	6 inches.

The shell-bed was underlain by quicksand bearing water.

In the vicinity of Manhasset, on the road to Port Washington, are extensive exposures of stratified sand, more or less inclined from the horizontal. About 200 yards south of the post office, on the west side of the road, is a bank about 40 feet high, composed of a white, coarse, laminated sand, streaked with hydrous peroxide of iron, the layers dipping S. E. 13°. A little northeast of the post office, along the road, there are banks of red sand cemented together in places by sesquioxide of iron and resembling the Cretaceous red sand bed of New Jersey.

On the shore of Manhasset Bay, near Port Washington, are high banks of coarse yellow stratified sand and gravel. This deposit is very irregular in its stratification, as it shows in many places the "flow and plunge" structure described by Dana, and which is evidently produced by swift currents. The depth of this formation cannot be determined, it is probably not less than 150 feet, and possibly is much greater. These beds dip about 15° W.; the strike is nearly due north and south. Along the shore of Manhasset Bay, from Port Washington to Barker's Point, are extensive banks of stratified sand and gravel, much stained with iron and dipping westward. At Prospect Point and Mott's Point, the banks are composed of coarse gravel similar to that at Port Washington.

Between Roslyn and Glen Cove, there are high banks of red and flesh-colored sands, while at Carpenter's clay pits a most interesting section is presented (fig. 1). The greatest hight of this section is 73 feet, the strike of the beds being N. 80° W. and the dip about 37° northerly. The layers here are composed of coarse white gravel and sand, apparently consisting of quartz, but susceptible of being easily crushed in the hand. The pebbles are traversed by innumerable cracks, and appear to have been subjected to the action of an alkaline solution. Interstratified with the gravel are layers of fine white clay, from six inches to one foot in thickness, stained pink in some places, and containing occasional fragments of a soft hematite or red ochre. Besides these beds, there is a deposit of kaolin farther south, but its stratigraphical relations to the layer exposed could not be determined. This kaolin is a soft white granular clayey substance, consisting chiefly of hydrous silicate of alumina from the decomposition of feldspar.

In fact the whole deposit would seem to be the decomposition product of a granulite rock such as occurs abundantly in Westchester Co., N. Y., and in southwestern Connecticut. In the north end of the bank is an unconformability, the gravel beds, which dip 37°, being overlaid by stratified sand dipping 15° in the same direction. The layers shown in this section form the north slope of an anticlinal flexure, the lowest beds being, I am informed by Mr. Coles Carpenter, one of the proprietors, almost vertical. An excavation made about 100 yards W. S. W. of the main pit, for the purpose of obtaining some leaf-prints, exposed the following section :

Gravelly drift, - - -	6 feet.	
White sand, - - - -		18 inches.
Coarse " - - - -		6 "
Reddish clay, - - - -	2 "	
Grey sandy carbonaceous clay with leaf-prints, - -	4 "	
	14 feet.	

These beds dipped about 15° S. W., the locality being on the south slope of the anticlinal. Owing to the sandy nature of the clay, and the dryness of the season, no satisfactory specimens could be obtained. The prints retain no carbon, but simply show the venation of the leaves.

North of Sea Cliff, along the shore of Hempstead Harbor, to the Glen Cove steamboat landing, is a series of clay beds outcropping on the beach and dipping N. by E. about 10° ; these beds are of various colors, blue, yellow, reddish, white and black. The reddish clays contain fragments of a soft hematite, and one of the blue layers is overlaid by about two inches of lignite in small fragments. Other layers contain pyritized lignite and nodular pyrites, but it is impossible to determine the nature and order of these beds accurately, without extensive excavations. Dark clays, with pyrites, are also reported to occur in Carpenter's pits at a considerable depth. In the beds of decomposed gravel already mentioned, are many geodes of sand cemented together by hydrous and anhydrous sesquioxide of iron, containing a dark granular mass which analysis shows to consist chiefly of decomposed pyrites. The conclusion is therefore justifiable that the nodules of marcasite which once existed in the gravel beds have decomposed by oxidation, and the resulting ferric oxide has cemented the sand about them into a hard crust, while the nodules in the clay beds which were protected from oxidation have remained unaltered.

North of Glen Cove, clays of various kinds occur at East and West Islands, Dosoris', and at Matinnecock Village. At the East Williston brickyard, near Mineola, there is a local deposit of grey micaceous clay. The depth of this, where excavated, varies from 7 to 18 feet. The clay overlies white laminated sands, stained with limonite, the upper surface of the sand being cemented together for the depth of an inch by the yellow oxide. Over the clay is about six inches of black alluvial earth.

At the brick-yard on Centre Island, in Oyster Bay, there is a deposit of brown sandy clay over a bed of more homogeneous and tougher clay. These beds undulate in an east and west direction or away from the shore, and the lower stratum contains shaly concretions or claystones. About a mile north of the brick-yard, it is said that a bed of white fire clay has been found at a depth of 25 feet under the drift and sand. A little west from the U. S. Fish Hatchery, at the head of Cold Spring Harbor, is a bank of stratified gravel 70 feet high. About 40 feet below the top of this bank is an exposure of laminated sand and sandy clay stained red, brown and yellow with oxide of iron, and a short distance below, a chalybeate spring issues from the bank. The clay deposit at Stewart's brick-yard, at Bethpage, is about 60 feet in depth. The surface stratum is a yellowish micaceous clay, the lower part being mottled blue and yellow. It probably was originally a gray or blue clay, its present yellow color being due to the peroxidation and hydration of the iron contained. Of this stratum there is about 35 feet; below is about five feet of reddish sandy clay, and beneath this a blue-black sandy clay containing nodules of white pyrites. This stratum is about 25 feet deep and is underlaid by white sand. The beds are somewhat disturbed and folded, the uppermost being slightly undulating, while the two lower appear to be raised in a fold trending nearly E. and W.

I am indebted to Mr. Lewis for the following section obtained in digging a well at Jericho in 1878, on the premises of Mr. Jules Kunz:

Surface loam, - - - -	15 ft.	
Drift, - - - - - -	36 "	
Yellow gravel, - - - -	81 "	
Sand, - - - - - -	15 "	
Sandy clay with a carbonized branch,	4 "	
Yellow clay, - - - - -	3 "	
Blue and gray sandy clay with pyrites,	30 "	
Micaceous sand, - - - -	14 "	6 in.
Total, - -	198 ft.	6 in.

From the same authority I have the following section of a well on Barnum's Island:

Sand and gravel, stratified, - -	70 ft.
Clay and clayey sand with lignite, -	56 "
Gravel and fine sand with clayey sand,	44 "
Blue clay, clayey sand and silt, with lignite and pyrites, - - -	168 "
Total, - -	338 ft.

In the third stratum, at a depth of 168 feet, a fragment of the stem of a crinoid was found which, together with a complete set of specimens from the well, is in the collection of the Long Island Historical Society. The fossil fragment is probably from some Palæozoic formation, and has no special importance.

At Crossman's brick-yard in Huntington, on the east shore of Cold Spring Harbor, we have the section shown in Fig. 2 of plate XXVII. The ridge which is intersected here trends a little E. of N. The section is as follows:

Till and stratified drift, - - -	10 ft.
Quartz gravel, - - - - -	45 "
Red and blue "loam" or sandy clay,	20 "
Diatomaceous earth, - - -	3 "
Yellow and red stratified sand, - -	20 "
Red plastic clay, - - - -	20 "
Brown " " - - - - - -	25 "
Total, - - - -	143 ft.

The bed of diatomaceous earth is of undetermined extent, and appears to be replaced a little to the east by a blue clay, which however contains some diatoms. It is undoubtedly equivalent to the bed of ochre which overlies the sand throughout the remainder of the section. At Jones's brick-yard, adjoining Crossman's, there is a similar fold nearly at right angles to the first, but the upper portion has been removed by ice or water down to the sand. This stratum, which is yellow and brown in the north part of Crossman's yard, is dark red in the south end and at Jones's. It appears to be mixed with a fine red clayey matter which separates on washing.

The formation on Lloyd's Neck is similar to that at Crossman's, with regard to the composition of the strata. On the north side of East Neck, at Eckerson's brick-yard, is a deposit of reddish clay underlain by brown clay very similar to that at Crossman's. To the west of this is a bank of white quartz gravel, while on the east is an extensive deposit of fine white quartz sand, laminated with red, yellow and brown waved streaks. The exact relations of these strata I was unable to determine, but from their analogies to other deposits I am inclined to consider the laminated sand as the more recent,

On the north end of Little Neck there is another large deposit of these laminated sands. At this point they dip S.E. about 15°. The following section given in Mather's Report Geol. of 1st Dist., p. 254, is more complete than any I could obtain at the time of my visit :

1.	Loose surface sand, - - - - - - -	$1\frac{1}{2}$ ft.
2.	Dark colored loamy sand and clay, - - -	3 "
3.	Yellowish and reddish sand, waved laminæ,	$3\frac{1}{2}$ "
4.	White sand tinged with yellow, - - -	4 "
5.	Sand similar but differing in color and direction of laminæ, - - - - - - - - -	4 "
6.	Sand red, waved laminæ, - - - -	30 "
7.	White clay, - - - - - - - - -	4 "
8.	White sand tinged with red or yellow, - -	4 "
9.	Clay, white like No. 7, - - - - - -	3 "
10.	Sand, white like No. 8, - - - - -	3 "

11.	White clay like No. 7,	5 ft.
12.	White sand like No. 8,	5 "
	Total,	70 ft.

South of this deposit, about half a mile, is a clay-pit which is worked by Capt. Sammis, of Northport. Here the stratification is as follows:

Surface loam and drift,	3 or 4 ft.
Sandy kaolin,	10 "
Yellowish clay,	4 "
Dark blue sandy clay,	15 "

Dip, 5° W.

The lowest stratum is separated into thin laminæ by equally thin layers of sand, in which are numerous impressions of fragments of vegetable matter, but only one leaf-print has been found; this is in the museum of the Long Island Historical Society. It is a small, broadly elliptical leaf, about $\frac{3}{4}$ in. long. In this same bed was found several years ago a shark's tooth which has been identified as *Carcharodon angustidens* or *megalodon.* It is difficult to determine the relation of this stratum to the other layers in the vicinity, but it is probably of the same period as the laminated sands, and seems to be identical with a bed which Mather describes as occurring on Eaton's Neck. (Geol. 1st Dist., p. 228.)

At the brick-yard near West Deer Park, beneath the gravel and drift, is a stratum of flesh-colored clay, underlaid by dark blue clay containing pyrites. I was informed by the owner, Mr. Conklin, that in the centre of the hill of gravel the clay rises up in a fold. Between Bethpage and West Deer Park is a deposit of ferruginous conglomerate and sandstone formed by the solidification of the stratified gravel and sand or yellow drift. This rock is very similar in composition and appearance to one which occurs in fragments in the glacial drift and contains vegetable impressions. At Provost's yard, near Fresh Ponds, are quite extensive beds of brown sandy clay, reddish clay, and chocolate-brown clay, dipping from the shore. The red and chocolate clays are probably identical with the similar beds at Crossman's in Huntington.

Lake Ronkonkoma is in a basin of which the bottom is about 210 feet below the high ground on the south. Its southern bank is composed of laminated sand streaked with oxide of iron, and the rest of the shore appears to be formed of the same material. At Crane Neck Point are bluffs, 60 feet high, of sand and gravel containing masses of ferruginous sandstone of recent date. At Herod's Point the bluffs consist of fine yellow sand and gravel, slightly stratified, and dipping a few degrees south. Limonite concretions are here abundant. The bluffs at Friar's Head are about 120 feet high, and consist of yellow stratified sand with pebbles. Over these is a dune of yellowish drifted sand 90 feet high, making the total hight of the peak 210 feet. On the west side of Robbin's Island is an exposure of blue clay overlaid by laminated ferruginous sand. The depth of this clay-bed has not been determined, but it is similar in appearance and quality to some of the clays near Huntington, especially at Crossman's brick-yard. A chalybeate spring issues from the laminated sand on the shore, a little to the south of the clay-pit. The clay bed appears to dip southward about 10° throughout the whole extent of the island. Near the railroad between Southold and Greenport are two brick-yards. At the more easterly of the two there are various deposits of stratified sand and clay very much folded and tilted. At this place the section exposed shows two parallel folds, the axes of which trend a little N. of E. The upper stratum of brown clay contains angular fragments of mica schist. (See fig. 3.) At the other yard they are working a bed precisely similar to that just mentioned and also containing angular fragments of rock.

On Shelter Island are high hills of gravel with a *thin* covering of till; the highest point is about 180 feet above tide. West of the village of Orient is a narrow isthmus of sand beach and salt meadow, about a mile and a half long and not more than ten feet above tide. East of this, on the north side of the peninsula, Brown's Hills extend along the shore for a mile and a half, the highest point being 128 feet above Long Island Sound. The structure of these hills is difficult to determine, as extensive land slides have occurred, and the slopes are covered with grass and bushes. One exposure gave the following section:

Drift, - - - - - -	3 feet.
Fine yellow sand, - - - -	8 "
Micaceous clay, - - - -	1 "
Micaceous sand, - - -	25 "
Total, - - -	37 feet.

The micaceous sand occurs at the foot of the bluffs along the shore in this vicinity. It may also be seen half a mile west of Orient, in a bank by the road-side.

On Gardiner's Island a very complete section is exposed on the southeast shore, which exhibits the strata to the depth of about 250 feet (see figs. 4 & 5). Here stratified sands and clays of various kinds and colors are raised up in two parallel anticlinal folds. In the southerly fold, the stratum is a light red, fine, plastic clay, very similar to that at Crossman's in Huntington; it is here exposed to a depth of about 100 feet and is upheaved at a high angle, its outer slopes dipping about 45°, while along the axis of the fold the laminæ are vertical. The northern anticlinal has about 15° dip on either side, and in its north slope is a stratum of yellowish clayey sand containing a bed of post-pliocene shells, at an average hight of 15 feet above the sea. The formation which is here brought to view probably underlies the whole of the island, as it is exposed at various other points. On the north and southeast shores the beds are very much disturbed and folded, and the surface of the island is raised in a series of parallel ridges corresponding in position to the folds and having a general trend of N. 65° E. The highest point on the island is 128 feet above the sea; the bluffs along the shore being from 25 to 70 feet high. The fossiliferous stratum is about 20 feet long and 4 feet thick, containing an abundance of shells, most of which appear to have been crushed by superincumbent pressure. The locality was visited in 1863 by Prof. Sanderson Smith, who describes the bed as 150 to 200 feet long. Prof. Smith has identified the following species* all of which are recent: *Nassa trivittata, N. vibex, Fusus decemcostatus, Purpura lapillus, Columbella lunata,* †*Natica duplicata, N. heros, Chemnitzia*

* Annals N. Y. Lyceum of Nat. Hist., Vol. VIII, 1865.

† Species also collected by the writer.

interrupta, Crepidula fornicata, **C. plana, Tornatella puncto-striata, Bulla canaliculata,* * *Venus mercenaria,* * *Ostrea Virginiana, Pecten Islandicus, P. Magellanicus, Arca transversa, A. pexata, Cardita borealis,* **Astarte sulcata* or *undata, Mactra lateralis, Lucina radula,* **Mya arenaria* ; fragments of a *Balanus ;* a coral, *Astrangia Danæ.*

Napeague Beach, east of Amagansett, is three miles long and one quarter of a mile broad, consisting entirely of white quartz sand. Along the shore on the north and south are dunes of drifted sand 20 or 30 feet high, but the main portion of the beach probably averages less than 10 feet above the sea. East of the beach, the country for twelve miles to the end of Montauk Point, is chiefly a terminal moraine, and as such I have already briefly described it.

Historical Geology.

Having thus reviewed in detail the various strata underlying the drift, we come now to consider their age and history. Without attempting to decide the geological equivalence of the crystalline rocks at Astoria, we will discuss the unsolidified deposits which have just been described.

From the position and strike of the Cretaceous strata in New Jersey and Staten Island, it has been surmised by geologists that they underlie Long Island throughout the whole or a portion of its extent. The locality at which the strata most resemble the Cretaceous beds of New Jersey is Glen Cove, where the clays already described are probably of this age. If the Cretaceous formation extends under the whole of Long Island it must occur at a very great depth, since deep sections at points east of Glen Cove do not reveal its presence.

In regard to this formation and the following, it should be understood that sufficient data have not yet been obtained to warrant an attempt to map out their extent. The only exposures are in vertical sections along the shore and in various clay-pits or similar excavations ; and there being an immense amount of quaternary material overlying them, no satisfactory degree of accuracy can be as yet attained in this regard.

* Species also collected by the writer.

The Tertiary strata of Long Island cannot as yet be identified with much more certainty than the Cretaceous. From their character and position we may surmise that the brown and red plastic clays of Huntington, Gardiner's Island and elsewhere, belong to the age in question, but we have no palæontological evidence except from the shark's tooth found on Little Neck, which would identify the bed in which it occurred as Eocene or Miocene. The stratified sands and gravels however, which overlie the supposed Cretaceous and Tertiary beds, and in turn are overlain unconformably by surface drift and till, we may accept as Post-pliocene, from the analogy of their composition, structure and position to the deposits of Gardiner's Island and Sankaty Head, of which the fossils determine the age beyond question ; unfortunately, however, there is no unconformability, to show where the Tertiary ends and the Quaternary begins.

At various times and places, fossil shells and lignite have been found on Long Island. I append a synopsis of a list of these compiled by Elias Lewis, Jr., from Mather's Report and from other sources :

	Nature of Fossil.	Locality and Date.	Depth.	Authority.
1.	Recent shells.	Ft. Lafayette.	23—53 ft.	E. Lewis, Jr.
2.	Pyrula, clam, oyster.	New Utrecht.	43—67 ft.	Thompson's Hist. of L. I.
3.	Clam and oyster shells.	Well in Prospect Park.		E. Lewis, Jr.
4.	Clam and oyster shells.	Well at Flatbush Almshouse.	40—50 feet.	" "
5.	2 Petrified clams	Flatbush.	100 ft.	W. J. Furman Antiquities of L. I.
6.	*Oxogyra costata*, with gr'n s'nd.	Bet. Brooklyn and Flatlands.	60 ft.	Dr. J. C. Jay, Ann. of Lyc. Nat. Hist., 1842.
7.	Oyster shells.	High grounds in Brooklyn.	73 ft.	Furman's Antiquities.
8.	Clam shells.	Fort Greene, 1814.	70 ft.	" "
9.	*Anomia ephippium.*	Cor. Jay & Front Street, Brooklyn.	15 ft.	E. Lewis, Jr.
10.	Oyster shells.	Nassau Gas Light Co., Williamsburg.	127 ft. 6 in.	" "
11.	Log of wood.	Bushwick.	40 ft.	Thompson's Hist.
12.	Shells.	Newtown.	70 ft.	" "
13.	Clam shells.	East New York.	80 ft.	" "
14.	Wood.	3 miles W. of Jamaica.	25 ft.	" "
15.	Clam and oyster shells.	Lakeville.	85 *ft. above tide* 140 to 160 tf.	Henry Onderdonk, Jr.
16.	Clam, oyster and scallop shells.	Lakeville.	200 *feet above tide.* 47 ft.	J. H. L'Hommedieu.
17.	Wood.	Great Neck, 1813.	50 ft.	Thompson's Hist.
18.	Oyster shells.	Manhasset, 1813.	78 ft.	" "
19.	Shells.	Bet. Manhasset and Roslyn.	140 ft.	" "
20.	Stem of Crinoid.	Barnum's Island.	168 ft.	E. Lewis, Jr.
21.	Lignite.	" "	100–383 ft.	" "
22.	Wood.	Near Westbury.	Great d'pths	Thompson's Hist.
23.	Wood.	Hempstead Plains, 1804.	100–108 ft.	Dwight's Travels.
24.	Carb'nized wood	Sea Cliff, 1845.	94 ft.	Isaac Coles.
25.	Lignite.	Glen Cove, 1864.	40 ft.	E. Lewis, Jr.
26.	Lignite.	Jericho, 1878.	96 ft.	" "
27.	Wood.	Cold Spring.	110 ft.	Thompson's Hist.
28.	*Carcharodon angustidens.*	Little Neck.		P. B. Sills.
29.	Log of wood.	Strong's Neck.	40 ft.	Thompson's Hist.
30.	Clam shells.	Shelter Island, 1898.	57 ft.	" "
31.	Shells.	Wells at Amagansett.		E. Lewis, Jr.
32.	Bones of Mastodon.	Jamaica Pond, 1846.		
33.	*Venus mercenaria*	Yaphank.	100 *feet above tide.* 20 ft.	E. Lewis, Jr.
34.	*Ostrea Virginiana*	Sag Harbor, 1864.	180 ft. *above tide.*	Dr. Cook.

In view of the fact that we have nowhere else any good evidence of a change of sea level amounting to 200 feet in the vicinity of New York during the Glacial epoch, we can only account for the high elevation of some of these fossils by supposing that they, with their containing beds, have been raised to their present position by glacial action in the manner I shall describe.

Of the physical conditions under which the presumed Cretaceous and Tertiary beds were deposited, we know nothing; though it is reasonable to conclude that they consist of the debris of New York and New England rocks carried down from the highlands and deposited along the coast by rivers or by other agencies of transportation. The overlying deposits of stratified gravel, sand and clay, part of which, as before stated, are equivalent to the "yellow drift" of New Jersey, are also difficult to account for. They consist largely of transported material from older beds, and by their structure indicate that they have been formed by swift currents which carried along and deposited coarse and fine material mingled together. Their fossils, so far as we know, exclude them from the Tertiary, and they underlie the drift unconformably, although by definition the Glacial period begins the Quaternary age.

If, however, we assume in the Quaternary a succession of glacial epochs, or alternate periods of advance and retreat of the ice-sheet, as suggested by Croll's theory, we can explain the origin of the beds in question by supposing that during the epoch of glaciation immediately preceding their deposition, the ice-sheet did not reach so far south, while the floods of of the succeeding warmer epoch modified and spread over the sea-bottom the drift thus formed.

In order to appreciate more exactly the relations of these Post-pliocene beds to the glacial drift, it will be necessary to consider some very interesting phenomena. Along the north shore of Long Island from Flushing to Orient Point, are exhibited most striking evidences of glacial action. We find the stratified gravels, sands and clays upheaved by the lateral pressure of the ice-sheet and thrown into a series of marked folds at right angles to the line of glacial advance, which, judging from the grooves and striæ on the rocks of New York and Connecticut, was about S. 30° E. The glacier having thus crumpled and folded the underlying strata, it evidently rode over them and continued its course southward, pushing before it an immense mass of sand and gravel, together with debris from the rocks of New York and New England.

The theory that Long Island Sound was a body of water previous to the arrival of the ice-sheet, would seem to be sustained by the character of the detritus deposited by the ice on Long Island. From Brooklyn to Whitestone, where the sound is narrow, the till or drift proper is quite conspicuous ; east of this it becomes less noticeable, and beyond Roslyn, as before stated, it does not again occur in abundance until we reach the vicinity of Greenport, where the Sound again grows narrow. This seems to be due to the fact that the finer debris of the northern rocks was carried along imbedded in the lower part of the glacier. The channel of the East River, owing to its narrowness, was filled up and passed over, the till being deposited to form the range of hills near Brooklyn ; but in crossing the broader part of the Sound, the ice probably lost the greater portion of its load of till, and only carried over the boulders which were on the surface or in the upper part of the glacier. On reaching the north shore of the island the alluvial gravel and sands were scooped up and pushed forward in front of the ice-sheet, to form the "moraine," and the boulders, when the ice melted, were deposited on the surface. The map shows that the principal bays on the north shore penetrate the land in a direction identical with that of the advance of the glacier. We may reasonably infer from this fact, that these indentations were ploughed out by projecting spurs of ice, and the inference is supported by the fact that the bays are walled in by high ridges which have been formed largely through the upheaval of the beds by lateral thrust. The best example of this displacement in the formation of a bay is shown in the section at Crossman's clay-pit in Huntington, (Fig. 2) which I have previously described. Harbor Hill, which stands at the head of Hempstead Harbor, is 384 feet high, and chiefly consists of gravel and sand more or less stratified. Jane's Hill, four miles S.S.E. of the head of Cold Spring Harbor, is 383 feet high, and is composed of the same materials. In the vicinity of each of these hills, moreover, there are other ridges and elevations averaging about 300 feet in height. Southeasterly from Huntington Bay we have the Dix Hills and Comac Hills rising about 250 feet. Southeast of Smithtown Harbor, we have Mt. Pleasant, 200 feet in height; in a like direction from Stony Brook Harbor, are the Bald Hills, also 200 feet high. Again we have Reulands Hill, which is 340 feet in height, and has the seme general bearing from Port Jefferson Harbor. About South 30° East from Wading River, where there is quite a deep valley, we find Terry's Hill, 175 feet high. South of Great Peconic Bay rise the Shinnecock Hills, 140 feet, and southeasterly from Little Peconic Bay are the Pine Hills about 200 feet high. From these instances it will be seen that the areas of high elevation bear a very marked geographical relation to the deep indentations of the coast. That this relation is due to glacial action, seems more than probable, as it can scarcely be an accidental coincidence that the highest hills on the island should be in a line with the deepest bays on the northern coast, and that the course of these bays should coincide with that of the glacier.

At every point along the north shore where a section of the strata is exposed, the flexed structure of the beds under the drift may be observed. On Gardiner's Island, these folds are remarkably prominent, the surface of the island being broken with numerous parallel ridges having a general trend N. 65° E. These ridges correspond to folds in the stratified beds, which the surface drift overlies unconformably, and as they are at right angles to the line of glacial advance it is difficult to conceive any agency which could have produced them except the lateral thrust of the ice-sheet, Unless these phenomena can be referred satisfactorily to some other cause, and of this I very much doubt the possibility, we have in these folds a strong argument against the iceberg theory, as it seems evident that a mere drifting berg could not develop sufficient progressive force to do the work here shown. A similar origin may be attributed to the ranges of hills which form the so-called "back-bone" of the island; as their structure indicates that they have been formed partly of gravel and sand transported from the north shore, and partly through the upheaval of the stratified beds by the friction of the moving mass of ice. As the downward pressure of the glacier was about 450 lbs. per square inch for 1,000 feet of thickness, and its progressive force was only limited by the resistance of the ice, it is quite reasonable to assume it capable of producing such a result. At one locality, West Deer Park, this is manifestly the case, and I have no doubt that in time it will be found generally true. The numerous springs that issue from the hillsides along the north shore also lead one to infer that the substratum of clay has been raised up in the centre of the hills. The occurrence of the springs might be accounted for hypothetically by supposing that these hills are the remnants of unequally eroded *horizontal* strata of sand underlaid by clay ; but this we know is not the case.

Mr. Upham, in his discussion of the moraines, attributes all the stratified deposits to diluvial and alluvial action in the Champlain period, to which the Gardiner's Island deposit has been erroneously referred. He also concludes that the more southern drift hills, which are from 200 to 250 feet high, were formed in ice-walled river-channels formed upon the surface of the glacial sheet when rapidly melting. That this process has taken place in some cases, is quite probable, as there are undisputed kames in certain places, but from the analogy of the deposits in question to the others described, I am inclined to refer them generally to the same causes.

The changes which have occurred on Long Island since the retreat of the glacier, have been mainly topographical, and unquestionably very extensive. The streams of the Champlain epoch carried down the drift from the morainal hills and distributed it on the plain to the south, forming in many places local beds of clay. In the vicinity of Bethpage and elsewhere, are hillocks of stratified sand similar in appearance to the New England kames. The valleys mentioned above, which have been examined by Elias Lewis, Jr., are unquestionably the channels of streams resulting from the melting of the glacier.

The coast line of the island is rapidly changing, on account of the action of the swift westerly currents which are wearing away the east end and depositing the sediment along the north and and south shores. By this means the bays which open into the Sound are rapidly becoming shallow. The Great South Beach is also an evidence of the action of the waves and currents in changing the outline of Long Island. We have moreover abundant evidence that the south shore has been gradually sinking.

This subsidence probably began in the later Quaternary and may be still continuing.

Economic Geology.

Magnetite : this is the only metallic ore found on Long Island, and occurs almost everywhere on the beaches in the form of sand. It is not, however, sufficiently abundant in any one locality to render its collection profitable. A company was started some time since for the purpose of separating the ore, in the vicinity of Quogue, from its associated quartz and garnet sand by means of powerful electro-magnets, but the enterprise proved unsuccessful.

Iron Pyrites in its white variety, or marcasite, is common in the lower clay-beds, but does not occur in sufficient abundance to pay for utilizing it.

Lignite occurs only in small quantities and usually at great depths.

Peat of an inferior kind, composed of the matted roots of grasses and other plants, occurs at the heads of most of the bays on the south shore, but is not used to any extent.

Although not productive of any of the valuable minerals, Long Island may be considered peculiarly rich, from the fact that almost the whole of the island can be utilized in the arts and trades. Its sands and gravels are of every kind in use, and its clays are suited for the manufacture of fine grades of brick and pottery. The former materials are largely shipped from Port Washington and the vicinity, for building purposes.

The most extensive deposit of fine pottery clay occurs at Glen Cove, on the premises of the Messrs. Carpenter. This clay is very plastic and burns a light cream-color. The friable quartz pebbles described above, produce when ground the finest quality of white sand for glass and pottery. The deposit of kaolin is also unsurpassed. In addition to these materials, this locality furnishes fire-sand for pottery, grey and blue pottery clays, and an excellent fire-clay.

The next locality of note is Huntington. In this town is an immense deposit of the finest brick-clay, upheaved to such an elevation that it is easily accessible. The beds are worked at

Crossman's and Jones's brick-yards, and extend throughout Lloyds' Neck. Between Huntington and Cold Spring a large deposit of white pottery-clay has been worked for many years. The brick-clay extends east over ten miles, and is worked at Eckerson's yard on East Neck, and Provost's at Fresh Ponds. At Eckerson's and at Sammis's pits on Little Neck, are immense deposits of fire-sand which extend over Eaton's and Lloyd's Necks.

A little west of Greenport are two brick-yards at which a bed of glacial clay is being worked. Between these two yards is a bed of mottled blue clay used for making flower pots. The most extensive deposit of all, however, is that on Gardiner's Island. This clay is unsurpassed for the manufacture of bricks, and from the abundant supply of moulding-sand and the easy accessibility of the locality by water, must in time prove an important source of revenue.

DESCRIPTION OF PLATE XXVII.

Fig. 1. Scale 1 inch=60 feet.

Section at Carpenter's clay-pits, Glen Cove, looking east.

a. Glacial drift.
b. Yellow sand.
c. Friable quartz gravel and sand.
d. Fire-clay.

Fig. 2. Scale 1 inch=60 feet.

Section at Crossman's brick-yard, Huntington, looking north.

a. Glacial drift.
b. Quartz gravel, stratified.
c. Sandy clay or "loam,"—upper half yellow, lower half blue.
d. Diatomaceous earth mixed with clay.
e. Yellow sand, stratified.
f. Red laminated clay.
g. Brown laminated clay.

Fig. 3. Scale 1 inch=30 feet.

Section at Fulmer's brick-yard, Greenport, looking north.

a. a. Reddish glacial clay, with fragments of mica schist.
b. Red clay.
c. Micaceous sand, laminated.

FIGS. 4 & 5. SCALE 1 INCH=60 FEET.

Section on southeast shore of Gardiner's Island, looking west.

a. Glacial drift.
b. Laminated white sand.
c. " white sand streaked with limonite.
d. " yellow and blue clayey sand.
e. " white and yellow sand.
f. " grey and yellow sand.
g. " yellow sand with blue clay.
h. " grey sand with red clay.
i. " red clay and grey sand.
j. " grey sand with red clay.
k. " sand, top streaked with limonite.
l. Dark greenish clay.
l' " " " somewhat granular.
m. " grey clay and sand, laminated.
m' Beach sand streaked with limonite.
n. Laminated sand, stratification obscured by a slide and possibly interrupted by a fault.
o. Laminated greenish sand.
p. " white and yellow sand.
r. " green and yellow clayey sand.
s. " reddish clayey sand with fossil shells.
t. Dark greenish clay.
u. Fine laminated sand.

PLATE XXVIII.

Map of Long Island, showing the southern limit of glacier action. (Prepared on the basis of the U. S. Coast Survey Map.)

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XXI.—*On the Variation of Decomposition in the Iron Pyrites; its cause, and its relation to density.*

BY ALEXIS A. JULIEN.

Read April 26, 1886.

The popular name, iron pyrites, comprises three distinct mineral species, pyrrhotite, marcasite, and pyrite, all consisting of combinations of iron and sulphur, and differing in method of crystallization, density, hardness, color, and other properties. It is well known that these three minerals differ in their modes and degrees of decomposition, when exposed to the weather in outcrops of rock, masonry, and heaps of mined coal. But there are equally decided differences in the methods of weathering in varieties of one of these minerals, pyrite, which have not yet been generally recognized, and whose cause yet remains unexplained.

Two general processes of decomposition of these minerals occur at the ordinary temperatures of the atmosphere.

1. Envelopment by a crust, and finally complete alteration into compact iron oxide, generally in some hydrated form, accompanied by a trace of sulphuric acid and sometimes by free sulphur.

This process is generally slow, and probably conditioned upon a limited supply of moist air, and sometimes upon precipitation by basic solutions, *e. g.*, of earthy or alkaline carbonates.

Pyrite is commonly attacked in this way, and sometimes marcasite and pyrrhotite.

2. Conversion into copperas and other iron-sulphates, often with the development of free sulphuric acid, generally accompanied by the production of more or less hydrated iron-oxide; this process is always attended by a splitting up of the mass, and its minute disintegration effected by the crystallization of the copperas, with a similar rending action to that which is exerted by frost.

This process is rapid and implies apparently, in most cases, an abundant supply of moist air and rapid oxidation, but protection from the flow of meteoric waters.

Marcasite is distinguished by its ready subjection to this mode of weathering, which however often attacks nodular and concretionary pyrites of mixed constitution and some varieties of pyrrhotite.

For the clear understanding of the causes of these various phenomena of decomposition, it will be desirable to consider: first, the relationship of composition to density and other physical properties in the artificial and natural sulphides of iron, the origin and association of the latter, and their common modes of decomposition; and, secondly, the variation of decomposition in pyrite, its probable cause, and the modes of discrimination between stable and unstable varieties of the mineral.

Part I.

The Sulphides of Iron.

There are three iron sulphides theoretically recognized in chemistry, but of even these the existence of one cannot yet be regarded as established. They may be artificially prepared, in conditions of uncertain purity, by various methods.

Iron protosulphide, or ferrous sulphide, Fe S. When prepared by the process of Gahn, stirring a white-hot rod of iron in molten sulphur, it forms "a yellowish crystalline mass, having a metallic lustre, and sometimes crystallizing in hexagonal prisms,"[1] with specific gravity of 4.69. But when prepared by throwing a mixture of three parts of iron filings and two parts of sulphur into a red-hot Hessian crucible, "it is thus obtained as a black porous mass, which at a higher temperature fuses, solidifying to a greyish yellow, crystalline metallic mass of specific gravity 4.79."[2]

Rammelsberg,[3] by heating octahedral pyrite from Elba in hydrogen, prepared it of a specific gravity 4.694; and Rose,[4] by

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[1] Roscoe and Schorlemmer, Treat. on Chem. (1880), II, 118.
[2] Frankland and Japp, Inorg. Chem. (1884), 766.
[3] Pogg. Ann. (1864), CXXI, 337.
[4] *Idem* (1849), LXXIV, 301.

heating ferric oxide with excess of sulphur, and removing the excess of the latter by heating in dry hydrogen, obtained it as a porous and blebby net-work of little flakes and plates, with a specific gravity of 4.726, in coarse powder at 9°.8 C.

These forms are readily soluble in dilute acids, with evolution of hydrogen sulphide; but if prepared by ignition of ferric oxide in an atmosphere of hydrogen sulphide, it is found to be insoluble in cold dilute hydrochloric acid.[5]

A hydrated form, Fe S, H_2O, can be prepared, which is soluble in dilute acids, even to some degree in carbonic and organic acids.

Iron disulphide, $Fe S^2$. Wöhler heated slowly an intimate mixture of ferric oxide, sulphur and sal ammoniac, above the temperature at which the last substance volatilizes, and obtained the disulphide in small brass yellow octahedra and cubes. Rammelsberg.[6] by reduction of ferric oxide in hydrogen, and heating with sulphur below ignition, obtained the disulphide. In neither case is the density reported. It is not attacked by dilute acids or by cold concentrated sulphuric acid, but readily decomposed and dissolved, with separation of sulphur, by nitric acid, aqua regia, and boiling concentrated sulphuric acid.[7]

A third intermediate compound, *iron sesquisulphide*, or diferric trisulphide, $Fe^2 S^3$, has been formed artificially. It has been prepared by Rammelsberg, by gently heating iron and sulphur together, as a powdery mass of specific gravity 4.41; also, by the action of hydrogen sulphide on ferric oxide at a temperature below 100° C. If obtained at a red heat, it forms a yellow, non-magnetic, metallic mass, which has a specific gravity 4.4, and is decomposed by dilute sulphuric and hydrochloric acids into hydrogen sulphide, ferrous sulphate, and iron disulphide.[8]

Gray, bronze-colored and bronze-yellow powders have been also prepared by Rammelsberg and Proust, which are magnetic, possess the composition $Fe^7 S^8$, and in one case a specific gravity

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[5] Ebelmen, Ann. Ch. et Phys. (3), XXV, 97.

[6] *Loc. cit.*

[7] Berzelius, Lehrb., II, 723—725.

[8] Berzelius, *loc. cit.*

4.494. Two other compounds have been prepared by Arfvedson, to which he assigned the formulas, $Fe^8 S$ and $Fe^2 S$.

Of these iron sulphides, there are probably but two of whose occurrence in nature we have any certain knowledge, viz., the Proto- and Disulphide.

Iron protosulphide, Fe S, containing in 100 parts : iron, 63.64, and sulphur, 36.36.

This substance has not been recognized as an individual mineral on our globe, except in the form of the foreign mineral *troilite,* which occurs in many fallen aerolites.

The nature of this interesting mineral has been shown by many analyses, of which it will suffice to present one by J. Lawrence Smith, on troilite derived from the aerolite which fell in Sevier County, Tenn. : iron, 63.80, and sulphur, 36.28.

The specific gravity of the mineral varies in different stones from 4.681 to 4.817.

As this mineral has separated from fusion, and owes its origin to extra-terrestrial agencies and conditions of which we are entirely ignorant, it cannot be safely used for discussion in relation to the density of the iron sulphides of our own planet.

In the black mud of ditches, pools and salt-marshes, of flats at low tide, and that between the stones of city pavements, in peat, and in trunks of trees lying submerged along the sea-beaches, the presence of an amorphous iron protosulphide has been verified, in black particles, without metallic lustre, readily decomposable by hydrochloric acid,[9] or even by exposure to the air, with an efflorescence of copperas.

The sulphide occurs, also, in combination with nickel sulphide, in the form of a single bronze-colored mineral, *pentlandite,* an ore of nickel, first found at Lillehammer, Norway, and whose composition, according to Rammelsberg,[10] is as follows: iron, 40.60 ; sulphur, 36.64 ; nickel, 21.07 ; and copper, 1.78. Specific gravity, 4.6.

Separating the intermixed chalcopyrite (5.14 per cent.) represented in this analysis, the mineral is found to consist of iron sulphide (Fe S), 64.73, and nickel sulphide (Ni S), 34.45.

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[9] A. Daubrée, Études Syn. de Géol. Expér., (1879), 87.

[10] Pogg. Ann. (1864), CXXI, 337.

Iron disulphide, $Fe\ S_2$, containing in 100 parts: iron, 46.67, and sulphur, 53.33.

This combination is dimorphous, *i. e.*, assumes two forms of crystallization in nature, and thus constitutes two minerals, *marcasite* and *pyrite*, of very common occurrence. There is also another natural form of iron sulphide, the mineral *pyrrhotite* or magnetic pyrites, whose composition and formula intervene between those of the proto- and disulphides. The distinctive characteristics of these three kinds of pyrites may be tabulated as follows:

	Pyrrhotite.	*Marcasite.*	*Pyrite.*
Composition, -	$Fe^5\ S^6$ to $Fe^{16}\ S^{17}$, and commonly nickeliferous.	$Fe\ S^2$.	$Fe\ S^2$.
Hardness, -	3.5—4.5.	6.—6.5.	6.—7.
With steel, -		Striking fire imperfectly, with strong sulphurous odor.	Striking fire readily, with weak sulphurous odor.
Specific gravity,	4.4—4.68.	4.68—4.85.	4.74—5.19.
Color, -	Bronze-yellow to steel tomback-brown.	Grayish white to bronze-yellow.	Golden to pale brass-yellow.
Streak, - -	Grayish black.	Greenish gray to brownish black.	Brownish black.
Fracture, - -	Uneven.	Uneven.	Conchoidal to uneven.
Grains, - -	Compact and magnetic.	Columnar structure.	Often fibrous and radial.
Crystals, - -	Rare: hexagonal, generally tabular, and magnetic.	Common: orthorhombic, often in striated twins, toothlike or crested forms, etc.	Abundant; isometric, cubes, pyritohedra, octahedra, etc.
Ignition in closed tube,	Unchanged.	Yielding sublimate of sulphur and magnetic residue.	(Like marcasite.)
In nitric acid, -	Insoluble.	Soluble with separation of sulphur.	(Like marcasite.)
In hydrochloric acid, - -	Soluble with separation of sulphur and hydrogen sulphide.	Insoluble.	Insoluble.
Alteration, -	Iridescent tarnish.	Iridescent, often efflorescent.	Iridescent, efflorescent, or hepatic.

It is not easy to make a comparison of actual analyses of pure crystals of these minerals with the densities obtained, as most of the analyses have been made upon massive forms for commercial purposes. From the scattered literature of the subject the following tables have been compiled. The full details of chemical composition and density are the more required for our purpose in that they are but meagerly presented in all the treatises on mineralogy—the analyses of pyrite being generally entirely omitted.

Pyrrhotite.

Synonyms—Magnetkies (Hausmann), pyrite magnétique, magnetic pyrites, pyrrhotine (Haidinger), rhomboedrischer eisenkies (Mohs).

The results of all the chemical examinations of this mineral by various analysts, have been very fully presented by H. Habermehl, in his excellent paper,[11] and need not be repeated here.

These analyses yield formulas which vary widely, thus:—$Fe^5 S^6$, $Fe^6 S^7$, etc., up to $Fe^{16} S^{17}$, the mineral apparently consisting of some form of combination of molecules of Fe S with a vayring number of $Fe S^2$; or, according to another view, of Fe S with $Fe^2 S^3$. To determine whether this form of combination be a true chemical compound, an isomorphous mixture of sulphides, or a mere mechanical mixture of Fe S with $Fe S^2$, $F^2 S^3$, or S, has been the object of much investigation. The analyses by Habermehl of fifteen samples, successively separated by the magnet from the pulverized mineral of Bodenmais, show, by their accordant results, that the last theory, that of mechanical mixture, may be put aside as impossible.

The fact that, on solution of most varieties of pyrrhotite in hydrochloric acid, only sulphur is left behind, although $Fe S^2$ is in every other form insoluble, has been considered an objection to the supposition of the presence of iron disulphide. Its minute molecular subdivision may perhaps account for its solubility in this instance, but the question still remains unsettled.

In the following table are presented all the published deter-

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[11] Ber. d. oberhess. Ges. f. Natur. u. Heilk. (1879), XVIII, 83, and Jahrb. f. Min. (1880), II, 303.

minations of specific gravity on this mineral, which I have been able to find. Those varieties were nickeliferous (from 3 to 11 per cent.), whose localities are given in italics.

No	*Locality.*	*Sp. Gr.*	*Analyst.*
1	*Horbach, Baden,* - - -	4.700	C. Rammelsberg.
2.	*Klefva, Sweden,* - - - -	4.674	J. Berzelius.
3.	Freiberg, Saxony, - - -	4.642	Lindström.
4.	Elizabethtown, Ontario, Can., -	4.642	J. Lawrence Smith.
5.	Trumbull, Conn., - - -	4.640	C. Rammelsberg.
6.	Locality unknown, - - -	4.631	Mohs.
7.	Utö, Sweden, - - - -	4.627	Lindström.
8.	Conghonas do campo, Brazil, -	4.627	O. F. Plattner.
9.	Locality unknown, - - -	4.623	C. Rammelsberg.
10.	Bodenmais, Bavaria, - - -	4.622	H. Rose.
11.	Bodenmais, Bavaria, - - -	4.622	Schaffgotsch.
12.	Elizabethtown, Ontario, Can., -	4.622	Harrington.
13.	*Locality unknown,* - - -	4.609	C. Rammelsberg.
14.	Boden, Saxony, - - - -	4.605	Breithaupt.
15.	*Craigmuir, Scotland,* - - -	4.602	D. Forbes.
16.	Kongsberg, Norway, - - -	4.584	Lindström.
17.	Auerbach, Germany, - - -	4.583	Petersen.
18.	Harzburg, Germany, - - -	4.580	C. Rammelsberg.
19.	*Hilsen, Norway,* - - - -	4.577	" "
20.	Xalastoc, Mexico, - - - -	4,564	" "
21.	Bodenmais, Bavaria, - - -	4.546	Schaffgotsch.
22.	*Gap Mine, Pa.,* - - - -	4.543	C. Rammelsberg.
23.	Bodenmais, Bavaria, - - -	4.540	V. Leuchtenberg.
24.	Cornwall, England, - - -	4.518	Hatchett.
25.	Moël Aelion, Wales, - - -	4.518	Hatchett.
26.	Treseburg, Harz Mts., - - -	4.513	C. Rammelsberg.
27.	Dobschau, Hungary, - - -	4.510	Breithaupt.
28.	*Inverary, Scotland,* - - -	4 500	D. Forbes.
29.	Artificial, by ignition of pyrite, -	4.494	C. Rammelsberg.
30.	Piedmont, - - - - -	4.270	Tournaire.
31.	*Gap Mine, Pa.,* - - - -	4.190	Boye.
32.	Rajputánah, India, - - -	2.580	J. Middleton.

Notwithstanding the repeated investigations which have been devoted to this mineral by the great company of eminent chemists, some of whose names are stated in this table, the question of the true signification of the varying composition of this species, it is acknowledged, remains still unsettled. As every fact bearing on this subject may have some value, I will present below some results of the comparison of the chemical composition and density of the varieties of pyrrhotite. For this purpose, we will accept the analyses as corrected by Habermehl, though carrying them out to 100 per cent., when necessary. All the analyses of nickeliferous varieties are omitted from consideration, as well as those of material whose density has been evidently decreased by the presence of light impurities, such as limonite (No. 26) and quartz (No. 30), and also the abnormal figures of the analyses of Hatchett, Middleton, etc. (Nos. 24, 25, 31 and 32). Some of the determinations of specific gravity, presented in the preceding table, were unaccompanied by analyses (Nos. 6, 14 and 27). The sixteen remaining varieties have been arranged in the order of decreasing density, and divided, as nearly as possible, into three groups as they stand.

		COMPOSITION.		
No. of Variety.	*Sp. Gr.*	*Fe.*	*S.*	FORMULA.
3	4.642	60.75	39.25	
4	4.642	60.41	39.59	
5	4.640	60.76	39.24	
7	4·627	61.44	38.56	
8	4.627	59.93	40.07	
9	4.623	60.26	39.74	
(*Average of group.*)	(4.633)	(60.59)	(39.41)	$Fe^7 S^8$
10	4.622	60.97	39.03	
11	4.622	61.18	38.82	
12	4.622	60.81	39.19	
16	4.584	60.75	39.25	
17	4.583	59.82	40.18	
(*Average of group.*)	(4.607)	(60.71)	(39.29)	$Fe^8 S^9$
18	4.580	60.83	39.17	
20	4.564	61.30	38.70	
21	4.546	61.15	38.85	
23	4.540	61.16	38.84	
29	4.494	60.76	39.24	
(*Average of group.*)	(4.545)	(61.04)	(38.96)	$Fe^9 S^{10}$

In his discussion of the constitution of pyrrhotite, Rammelsberg states the opinion: "the density (volumgewicht) leads to no conclusion, since the lightest show the same composition as the heaviest, to wit, about $Fe^9 S^{10}$." Now, in fact, most of the analyses of pyrrhotite (as well as of the other iron pyrites) were partial and therefore imperfect, consisting only of a determination of the amount of iron, that of sulphur having been estimated from the difference, by deduction from 100. But if we can trust the accuracy of the figures in this table, the significant fact appears to be brought out that an increase in the amount of iron and a corresponding decrease in that of sulphur are accompanied by a decrease of density. This at least suggests a confirmation of the view that we may have in this mineral an association, in some form of replacement or combination, of iron protosulphide, Fe S, having a specific gravity of about 4.4 or 4.5, as before estimated,—with iron disulphide, $Fe S^2$, of specific gravity equal to 5.0, the density of the varieties of pyrrhotite increasing with the proportion of iron disulphide. Nor is it necessary to conceive, it appears to me, that the disulphide in combination must possess the physical properties of one of its crystallized forms, pyrite or marcasite. It may be decomposable by acids, and this may account for the fact that not pyrite but sulphur is left on digestion of pyrrhotite in hydrochloric acid.

We may here refer to the ingenious suggestion of L. Bombicci,[12] that pyrrhotite may be simply made up of the regular association of two octahedral or isometric elements, *i. e.*, of true pyrite, $Fe S^2$ and of magnetite, $Fe^3 0^4$, in the proportion of 4: 1; *i. e.*, $4 Fe S^2 + Fe^3 0^4 = Fe^7 S^8 0^4$. Though the absence of oxygen in pyrrhotite is inconsistent with this hypothesis, it has served to suggest that there may yet be found in this mineral some analogous association of molecules of isometric pyrite, $Fe S^2$, and of iron protosulphide, Fe S, which, like pyrrhotite, was found by Gahn "sometimes crystallizing in hexagonal prisms." The analyses of varieties of pyrrhotite, beginning with the formula $Fe^5 S^6$, have at last reached $Fe^{16} S^{17}$, and it seems likely that some variety may soon be found in which the relationship of iron and sulphur will be as 1 to 1. The normal composition of this mineral may then indeed be, as was held by Frankenheim, that of iron protosulphide; and it is a plausible hypothesis that, from natural conditions of paragenesis, more or less pyrite, $Fe S^2$, in octahedra, may be generally intermixed through the native mineral in conformity to crystallographic symmetry, and also enclosed in its artificial form, left as a residue on the ignition of pyrite.

Weathering of Pyrrhotite.

The extent of the distribution of this mineral and its abundance are comparatively so limited that its mode of decomposition appears to have been little studied.

[12] Nuovi studj sulla Poligenesi dei minerali, Mem. Acc. Sci. Ist. Bologna (1883), 27, 28.

According to Senft,[13] it decomposes slowly, but, according to Roth,[14] more easily than pyrite, into copperas and reddish brown iron-oxide. Copperas was observed on pyrrhotite, near Bodenmais; sulphate of iron and nickel on nickeliferous pyrrhotite, at Horbach; limonite, pseudomorphous after pyrrhotite, near Ehrenfriedersdorf; and göthite after pyrrhotite, at Waldenstein, Carinthia. These indicate the hepatic mode of alteration. G. W. Hawes[15] stated, that, in New Hampshire :—

"The magnetic pyrites do not decompose so readily as ordinary pyrites. I have seen some gneiss from our State in buildings, and though the stone was sprinkled with particles of magnetic pyrites, it had not become stained by long exposure to the weather."

Prof. C. H. Hitchcock[16] corroborated this view :—

"One thing should be said of this impurity in the Hanover rock. There is a building on Corey Hill, containing pieces of the pyrrhotite as large as beechnuts; and, though the house has been standing nearly seventy years, there are scarcely any iron stains upon it. This species of pyrites sustains itself so well that oftentimes its presence need not be feared. A more remarkable instance of the ability of this pyrites to resist decomposition may be seen in the Francestown soapstone. I have examined many of the stoves manufactured from this stone, and noticed that bright particles of this pyrites were thickly sprinkled through it. I have also looked at pieces of this steatite that had been subjected to great heat without much change. It would appear, therefore, that this mineral may not be injurious to granites, as it seems to withstand successfully the vicissitudes of both heat and cold."

On the other hand, D. Forbes[17] stated, in regard to the pyrrhotite ore of Inverary, Scotland :—

"After some time, on exposure to the air, the mineral crumbles to pieces, some specimens breaking up after a few months, whilst others have resisted as many years."

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[13] Lehrb. d. Min. u. Fels. (1869), 176.

[14] Allg. u. chem. Geol. (1879), I, 103.

[15] Geol. of New Hampshire (1878), Pt. IV, 31.

[16] The Geol. of New Hampshire (1878), Pt. V, 80.

[17] Phil. Mag. (1868), 4th Series, XXXV, 179.

Grains of brass-yellow pyrite were enclosed in this ore, and "when the pyrrhotine fell to powder by the action of the atmosphere, these particles were quite unaffected, and were seen to be so many irregular spheres of cupriferous iron pyrites which externally retained still a sort of skin or crust of pyrrhotine, but, on breaking, at once showed that the mass possessed the bright brass-yellow color characteristic of pyrites."

A specimen of crystallized pyrrhotite in my own possession, from Elizabethtown, P. Ont., Canada, exhibits a brilliant iridescent tarnish, but no farther indication of decomposition.

It appears difficult to avoid the belief that we have, in these conflicting observations concerning the stability of pyrrhotite, results merely corresponding to the varying chemical constitution of the mineral; and that the indications of stability have probably accompanied the increased proportion of sulphur, or rather of the higher combination, iron disulphide—those of instability, the predominance of iron protosulphide and nickel sulphide. It appears certain that both stable and unstable varieties exist.

PYRITE.

Synonyms.—Schwefelkies, eisenkies, pyrite jaune, pyrite martiale, iron pyrites, cubic pyrites, mundic (term used in mines of Cornwall), sulphur (term used in coal mines, clay pits, etc.), iron (term used in marble quarries), coal brasses (term used in the manufactories of sulphuric acid).

Pyrite usually presents itself in opaque and brittle crystals of yellowish color, brass-yellow when pure, of splendent lustre, and possessing cubical, octahedral and other isometric forms; also in scales, seams, and granular nodules, often with radiated structure, and commonly stained by reddish-brown films, or even coated or penetrated by ochreous crusts of the same color.

The best analyses of crystals or pure material, and determinations of density, have been gathered into the following table, in which those percentage figures for sulphur, evidently obtained merely by deduction from 100, are enclosed in brackets. Although the composition closely approximates that of iron disulphide, it is probable that traces of impurities are constantly present, *e. g.*, gold, copper, silver, nickel, cobalt, zinc, lead, tin, thallium, selenium, and arsenic; these must exert more or less effect upon the density.

ANALYSES OF PYRITE.

No.	Locality.	Analyst.	Fe	S	Impurities.	Sp. Gr.	Kind of Material.
1	Cornwall, England,	Hatchett.[18]	47.85	(52.15)		4.830	Pentagonal dodecahedra.
2	" "	"	47.50	(52.50)			Striated cubes.
3	" "	"	47.30	(52.70)		4.831	Smooth polished cubes.
4	England, -	R. D. Thompson.[22]	45.07	53.35	SiO^2, 0.80 ; Mn 0.70.		"Coal brasses."
5	....	Berzelius.[23]	46.08	(53.92)			
6	....	"	45.74	(54.26)			
7	Philippshoffnung Mine, near Siegen,	Schnabel.	46.53	(53.39)			Compact. Crystals.
8	Heinrichssegen, near Müsen, - -	"	46.50	(53.50)			
9	Tuscany, - -	Clapham.[22]	44.50	(48.40)	SiO^2, 3.6 ; loss, etc., 3.5.		
10	Lockenhaus, Hungary,	A. Eschka.[19]	40.60	48.28	Zn, 3.59 ; Cu, 0.22 ; clay, 6.43.		
11	Namur, Belgium, -	C. V. Hauer.	40.95	(51.03)	Quartz, 8.02.	4.785	A crystal showing little whitish gray grains.
12	Belgium, - - -	Browell & Marecco.[22]	45.50	51.59	SiO^2, 2.20 ; loss, 0.28.		
13	Riotinto, Spain, -	L. de la Escossura.	41.80	49.88	Cu, 4.17 ; gangue, 4.15.	4.84	
14	Mine above Inverary Castle, Argyleshire, Scotland,	D. Forbes.[20]	45.73	49.32	Cu, 1.18; Ni, 1.99; Co, 1.24.	4.93	S. G., at 60° F. Grains enclosed in pyrrhotite.
15	California, - -	W. Lange.	46.46	52.93			Auriferous.
16	Davis Mine, Charlemont, Mass., -	G. Lunge.[21]	42.83	50.30	Cu, 3.07.		Granular.
17	Louisa Co., Virginia,	A. Voelcker.[24]	42.01	(48.02)	Fe^2O^3, 1.93 ; SO^3, 0.44 ; SiO^2, 7.60.		

ANALYSES OF PYRITE.—*Continued.*

No.	Locality.	Analyst.	Fe	S	Impurities.	Sp Gr.	Kind of Material.
81	Locality unknown,	C. V. Hauer.	45.53	(53.37)	Insol., 1.10.	4.925	
19	Sain-Bel, Rhone, -	A. Girard & H. Morin[25]	46.46	53.09	Insol., 0.37 ; moisture, 0.04.		Yellow and bright.
20	" "	" "	46.43	52.49	Insol., 0.90 ; moisture, 0.04.		" " "
21	Soulier, Gard, -	" "	46.07	52.58	Insol., 0.54 ; moisture, 0.51, As, 0.04.		Brilliant gray, with golden yellow iridescence.
22	Elba, - - - -	C. Mène.[26]	43.50	(52.20)	Si O^2, 4.00 ; alumina, 0.10 ; loss, 0.20.	4.801	
23	Conflens, Ariége, -	"	43.10	(52.40)	Si O^2, 3.50 : moisture, 0.20 ; alumina, 0.70 ; loss, 0.10.	4.810	
24	L'Allier, at Isserpent,	"	44.20	(52.70)	Si O^2, 2.50 ; moisture, 0.20 ; loss, 0.40.	4.803	
25	Cornwall, Pa., -	J. C. Booth.	44.47	53.37	Cu, 2.39.		

[18] Phil. Trans. (1804), XCIV, 325. [19] Berg. u. hüttenm. Jahrb. (1864), XIII, 47. [20] Phil. Mag. (1868), 4th Ser., XXXV, 178. [21] Dingl. Polyt. Jour. (1884), CCXLIX, 48. [22] *Idem* (1884), CCLII, 293. [23] Gilb. Ann. (1814), XLVIII, 164. [24] Trans. Am. Inst. Min. Eng. (1877–78), VI, 532. [25] Ann. d. Ch. et Phys. (1876), Sér. 5, VII, 229. [26] Compt. rend. (1867), LXIV, 870.

Density of Pyrite.

Locality.	*Analyst.*	Sp. Gr.	*Kind of Material.*
Freiberg,	Breithaupt.[34]	5.001	
"	"	5.007	
"	Mohs.	5.031	
Rio Marina, Elba.	C. Rammelsberg.[27]	5.027	Pentagonal dodecahedra.
" "	Kenngott and V. v. Zepharovich.[28]	4.976	Smooth and shining crystals, with minute black particles of included hematite.
" "	"	4.984	A similar crystal.
Elba or Piedmont.	"	5.012	A crystal with pure exterior, but not free from included foreign particles.
Piedmont, Elba, etc.	" [29]	5.000	Selected crystals, simple and modified cubes.
		5.002	
		5.017	
		5.018	
		5.019	
		5.020	
		5.023	
		5.024	
		5.026	
		5.028	
Traversella, Piedmont.	Breithaupt.[34]	5.078	Cube.
" "	"	5.097	
Piedmont ?	Kenngott and V. v. Zepharovich.[28]	5.112	Crystal.
"	"	5.027	"
"	"	5.185	"
Traversella, Piedmont.	C. Rammelsberg.[27]	4.967	Octahedra.
" "	Kenngott and V. v. Zepharovich.[33]	5.016	A crystal having little lustre, with little cavities over its surface occupied by brown iron-ochre.
Brosso, Piedmont.	" [31]	5.011	A crystal with smooth and brilliant surfaces, slightly striated.

[27] Zeits. d. geol. Ges. (1864), XVI, 268.

[28] Kenngott's Min. Notiz. (1855), No. 11.

[29] Sitzb. K. Ak. Wiss. in Wien (1853), XI, 392, (Kenngott's Min. Notiz., No. 5).

[31] Kenngott's Min. Notiz. (1855), No. 11.

[32] Zeitschr. d. geol Ges. (1864), XVI, 267.

[33] Kenngott's Min. Notiz. (1855), No. 11.

[34] Erd. Jour. f. pr. Chem. (1835), IV, 257.

Density of Pyrite.

(CONTINUED.)

Locality.	*Analyst.*	Sp. Gr.	*Kind of Material.*
Brosso, Piedmont.	Kenngott and V. v. Zepharovich.	4.807	A similar crystal.
" "	"	5.015	" "
" "	"	5.000	A crystal with surfaces somewhat attacked and corroded.
Compostella.	" [31]	4.779 4.800 5.053 3.769 4.891 3.930	Crystals with brown exterior, by partial alteration to limonite, with more or less yellow iron-ochre and unaltered pyrite within.
Toscana.	" [31]	4.925 4.920 4.930 4.922 4.916 4.878 4.853	Crystals having little lustre, but with impurities indistinguishable.
Compostella.	C. Rammelsberg.[32]	4.750	Crystal weighed unbroken, but with a cavity within which contained yellowish ochre.
Namur, Belgium.	Kenngott and V. v. Zepharovich,[33]	4.815 5.013 5.015 4.854 4.802 4.850 4.831 4.745 4.798 4.792 4.791 4.809 4.769 4.844 4.833 4.833 4.908	Crystals with smooth faces, shining or with little lustre.

[31] Kenngott's Min. Notiz. (1855), No. 11.

[32] Zeitschr. d. geol. Ges. (1864), XVI, 267.

[33] Kenngott's Min. Notiz. (1855), No. 11.

Density of Pyrite.

(CONTINUED.)

Locality.	*Analyst.*	Sp. Gr.	*Kind of Material.*
Tavistock, Devonshire.	Kenngott and V. v. Zepharovich,[33]	4.872 4.870 4.870 4.949 4.833	Crystals with strongly striated faces, quite pure in appearance, but showing, under a lens, the inclusion of little gray grains.
Locality unknown.	"	5.151 5.181 5.178 4.902 4.830	Crystal. " " " Crystal with upper surface colored brown.
Steiermark.	"	4.989	
Johanngeorgenstadt.	Breithaupt.[34]	4.960	Cube.
Kamsdorf near Saalfeld.	"	5.000	"
Kongsberg, Norway	"	5.158	"
Gouverneur, N. Y.		4.863	Pale bronze-colored, radiated, botryoidal, nickeliferous.
Annaberg.	Breithaupt.[34]	5.022	
Schneeberg.	"	5.029	

The results above given, concerning pyrite, afford us little means of exact comparison between chemical composition and density. Most analyses of the mineral have been made upon granular or massive impure varieties, for commercial purposes. In some cases selected crystals have been taken, but in none have we the means of judging by complete analyses, color, hardness, or other physical properties, how far the figures for density have been increased by the presence of gold, copper, etc., in the pyrite, or decreased by lighter impurities (quartz, etc.), by partial decomposition, by intermixture with other pyrites, or by the cavities enclosed in some beautiful crystal,

[33] Kenngott's Min. Notiz. (1855), No. 11.

[34] Erd. Jour. f. pr. Chem. (1835), IV, 257.

which the analyst could not find it in his heart to crush up for proper examination, and therefore weighed it as a whole.

In order to throw more light on this question, I present at the close of this paper a large number of determinations of specific gravity, on the mineral crushed to a coarse powder, in distilled water at 15° C. (60° F).

The results thus far obtained have demonstrated a coincident change of color and of density in varieties of pyrite possessing differing powers of resistance to oxidation. As to the signification of such change in density, it will be generally accepted that in every mineral possessing strong power of crystallization, the figure for specific gravity will remain invariable in all pure samples, probably to the third place of decimals. A determination made on coarsely powdered mineral, with the usual precautions, and at standard temperature, can only vary on account of enclosed cavities, the partial decomposition or alteration of the mineral, its original enclosure of foreign matter, isomorphous replacements of some one or more of its normal constituents by lighter or heavier substitutes, or on account of an internal rearrangement of its molecules into a dimorphous form of different density.

The influence of the enclosure of cavities is shown by the wide variation of the figures obtained by weighing entire crystals, *e. g.*, many of those of pyrite examined by Kenngott and V. v. Zepharovich, and the one by Rammelsberg, on pyrite of Compostella.

The influence of decomposition on the specific gravity has been abundantly illustrated already, as in the figures for the partially decomposed pyrite of Compostella, etc.

The influence of the enclosure of gangue, etc., is manifested in the lessened figures in analysis No. 14, and in the following analyses of both pyrite and marcasite, by C. Mène,[35] each set arranged in the order of increasing amount of impurities.

[35] Compt. Rend. (1867), LXIV, 870.

PYRITE.	*Fe.*	*S.*	*Earthy impurities.*	*S. G.*	
L'Allier, - -	44.2	52.7	3.1	4.803	At Isserpent.
Elba, - - -	43.5	52.2	4.3	4.801	In the specular ores.
Conflens, - -	43.1	52.4	4.5	4.810	Ariège.
L'Aude, - - -	43.5	49.1	7.2	4.743	Carcassonne.
Lavoulte, - -	42.9	48.7	8.2	4.771	
Allevard, - - -	42 1	48.5	8.9	4.750	Isère.
Gard, - - -	40.5	48.5	10·7	4.732	
Chessy and Sain-Bel,	39.3	46.5	14.0	4.621	

MARCASITE.					
Beauregard, etc., -	44.0	50.7	5.0	4.207	From ammonites.
Creusot, - -	32.5	49,1	8.0	4.181	From coal-beds.
St. Etienne, - -	42.3	48.5	8.6	4.180	From coal-beds.
Ain, - - -	42.0	48.2	9.6	4.182	From Oolite ore-beds.
Champagne, - -	40.9	46.4	12.2	4.176	Nodules.
Oise and Aisne, -	38.9	44.9	15.7	4.177	Bituminous pyrites.

It is thus well shown in each of these minerals, that, with the increase in the percentage of earthy impurities, *e. g.*, silica, alumina, lime, organic matter and water (passing down the fourth column), a corresponding decrease is generally shown in the specific gravity figures (passing down the fifth column).

Kenngott and v. Zepharovich found in their examination of pyrite-crystals, that, in those which were perfectly fresh and bright, the specific gravity lay between 5.0 and 5.185, but that, in the others, "through the intimate intermixture with quartz, or by incipient decomposition, it sank down to 4.8 and 4.7."

The influence of the partial substitution of isomorphous sulphide combinations of copper, nickel, etc., is presented in many analyses of pyrrhotite, and in Nos. 16 (balanced by the enclosure of light gangue) and 17 of pyrite.

Weathering of Pyrite.

On the exposure of this mineral to weathering, both of the main constituents, iron and sulphur, may combine with the oxygen of the air at the ordinary temperatures, in the presence of moisture, producing iron oxide, iron sulphates (copperas, etc.), sulphur, and even free sulphuric acid. When this action occurs in nature, the mineral becomes coated by the rusty stains and crusts of iron oxide already described. or even entirely transformed into it, while the enclosing rock in its vicinity may be stained or even corroded and disintegrated by the action of the free acid. Where the enclosing or neighboring material contains alumina, as in the common pyritiferous shales, whitish crusts of aluminum sulphates and of true alums effloresce over the weathered surfaces. This action is shown on very many of the rock-cuttings all over New York Island, by white crusts of astringent taste, on surfaces of the common pyritiferous gneiss, which have been exposed to the weather but a few years. The pyritiferous slates of the Mesozoic in Virginia,[36] the black shales of the Coal formation in Pennsylvania, the Cretaceous clays at South Amboy, N. J., and the shales of Strafford and Thetford, Vt., contain pyrite of the same perishable nature; and at the latter localities, advantage has been taken of this property to manufacture copperas and alum in large quantities, by the exposure of the mineral in moistened heaps to the action of the atmosphere.

It may also be remarked, in regard to the destination of sulphuric acid set free by pyritous decomposition, that, on its exposure to the air, the introduction of organic matter, as dust or in solution, must have resulted in its final deoxidation and escape as hydrogen sulphide, sometimes perhaps with a partial deposit in the form of free sulphur.

Again, Senft refers to the other mode of decomposition in pyrite :—

"In the air becoming variegated in color, and finally covered with a compact smooth brown crust; which then protects it against farther weathering."

In this process the mineral has lost its entire content of sulphur, which has been replaced by oxygen and by water, so that the iron has reached the maximum of oxidation and generally of hydration, probably thus:

$$4\,Fe\,S^2 + 15\,O^2 + 11\,H^2\,O = H^6\,Fe^4\,O^9 + 8\,H^2\,S\,O^4.$$

Where crystals of pyrite have been altered in this way, a mineral has been produced, retaining the form, exterior surface-

[36] O. J. Heinrich, Trans. Am. Inst. Min. Eng. (1877–78), VI, 274.

markings, lustre, and volume of the original substance (sometimes with a core yet unaltered), and with a brownish-red or liver-color, whence such pseudomorphs have been called *hepatic.* In regard to these, H. Bauerman[37] points out: "Here the proportion of the unaltered constituent, iron (46.7 per cent.), in the molecule of pyrites, is to that in the molecule of limonite (60 per cent.) as 1 to 1.3, while their specific gravities are in the inverse ratio of 1.4 to 1, or 5.0 for iron pyrites and 3.6 for limonite."

Where such crystals are enclosed in a rocky matrix, it has been suggested that galvanic or electro-chemical currents have been set in action by the introduction of moisture, through which the crystals of pyrite have been attacked from the outside, free sulphuric acid released, and a decomposition of the surrounding rock produced, sometimes with disintegration, or, in other cases, it may be, with consolidation, *e. g.*, by the production of gypsum.

A few instances of these pseudomorphs may be here presented from the works of Blum,[38] Roth,[39] etc., and from my own collection.

Limonite after pyrite:

Cubes, in Dutchess County, N. Y.; Yancey County, N. C.; Maryland, etc.

Octahedra, in New Jersey; in Llano and Bastrop counties, Texas, etc.

Göthite after pyrite:

In Saxony; at Berësowsk, Siberia; in Maryland; at Montevideo, etc.

Limonite and göthite, one enveloping the other or the reverse, *after pyrite,* or similar envelopments of limonite and compact red hematite, after pyrite, at numerous localities:

Striated cubes, sometimes six inches in diameter, in Switzer-

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37 Text-book of Syst. Min. (1881), 352.

38 Pseud. min. Reichs (1843), 187—197; Nachtrag (1847), 107, and (1863), 184, 185.

39 Allg. u. chem. Geol. (1879), I, 102—105.

land, Thuringia, Hungary, Piedmont, Scotland, Cornwall, Brazil, Africa, etc.:

Octahedra, at Schmalkalden:

Pentagonal dodecahedra, in Bohemia, Rhenish Bavaria, and Scotland.

Hematite and specular iron after pyrite:

At Ouval, Bohemia; at Hoy, in the Orkneys; at Kerrara, Scotland, etc.:

Cubes, at Triblic and Posedlitz, etc.:

Octahedra, at Frassem, near Arlon:

Pentagonal dodecahedra, at Lindenberg:

Pyritohedra, in Rio, Elba.

Magnetite, in little cubes *after pyrite*, near East Tarbet in Argyleshire, and near Portrush, Scotland,[40] etc.

However, the pseudomorphs in the crystalline iron oxides, both specular iron and magnetite, after pyrite, may owe their origin to more complicated processes of alteration, besides those concerned in mere decomposition by weathering.

Sulphur also is separated, in association with the hydrated iron-oxide, in many cases of the decomposition of pyrite (as at Bodenmais, Bavaria; at Frassem, near Arlon; at Burnt Hickory, Georgia, etc.), and also, in association with copperas, in that of marcasite (as at Schriesheim). Dr. J. S. Newberry states his observation of considerable quantities of free sulphur on the waste dumps of pyritiferous shales from the coal mines of Ohio. G. Rose observed at Beresowsk, Siberia, that the cubical cavities, left in the rock after the complete decomposition and removal of the pyrite crystals, still retained minute glittering crystals of sulphur.[41] As Senft remarks, "it has been proposed to explain this kind of decomposition by means of aqueous vapors" ("perhaps at elevated temperature," Blum), "which are decomposed by their reaction with the iron pyrites, and, by means of their oxygen, have altered the iron into hydrated oxide, while simultaneously their hydrogen has united

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[40] Roth, *op. cit.*, I, 235, 236.

[41] Reise nach dem Ural, I, 196 and 214.

itself with the sulphur of the iron pyrites to sulphuretted hydrogen, from which the sulphur has finally separated itself."

The reactions suggested are given in the following formulæ:

	2 molecules of pyrite	$Fe^2 S^4$,
plus	3 molecules of water have yielded	$H^6 O^3$,
	1 molecule of iron oxide	$Fe^2 O^3$ (afterward converted to hydrated oxide),
	3 molecules of hydrogen sulphide	$H^6 S^3$, and
	1 molecule of sulphur	S.

However, on this subject, it appears extremely unlikely that such a dissociation of the constituents of water could occur at ordinary temperatures, without the intermediation of a free acid, any more than in the case of the decomposition of water by metallic zinc or iron, or that of artificial iron sulphide. It has been shown by Stromeyer that, on the solution of pyrrhotite in dilute hydrochloric and sulphuric acids, there is an evolution of hydrogen sulphide and a separation of sulphur in fine powder. I would therefore suggest that we have probably, in these cases of the natural production of sulphur, the indications of a reaction with carbonic acid or some purely organic acid, very likely one of the humus group,[42] decomposing the iron sulphide—perhaps converting the iron into an organic salt, afterwards passing into peroxide and eliminating the sulphur as hydrogen sulphide and free sulphur, soon mechanically carried away in most cases.

This hypothesis appears to be justified by the observations of H. C. Bolton, who obtained a reaction for hydrogen sulphide, on digestion of pulverized pyrrhotite for twelve hours in a cold concentrated solution of citric acid. He says:—

"Three specimens of pyrite heated with citric acid gave no traces of the gas, and three of pyrrhotite liberated it both in the cold and freely on boiling. On the other hand, all the specimens named are decomposed by hydrochloric acid, except one

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[42] Proc. Am. Ass. Adv. Sci. (1879), XXVIII, 311.

specimen of pyrite (from Germany). It is evident then that citric acid may be used to distinguish pyrrhotite from pyrite."[43]

In a later experiment on the latter mineral alone, in which it was subjected to "prolonged contact with the same solution at the ordinary temperature of the workroom, say 60° to 70° Fahr.," he found that even "pyrite showed decided evidence of decomposition in eight days; one month later, the solution acquired a reddish-yellow color and reacted for iron and sulphuric acid."[44]

The powerful intervention of naturally acidified meteoric waters appears not to have been considered, in reference to the mode of weathering of pyrites now under discussion, but seems to be far more probably concerned in this alteration than the agent suggested to Rose by the proximity of the dyke at Beresowsk—aqueous vapor at elevated temperature. Percolating waters, acidified with carbonic and organic acids, are universally distributed and continuous in action, and the distribution of these interesting limonite pseudomorphs is equally wide, and their production apparently in constant progress. Another probable mode of the formation of these pseudomorphs, by precipitation in contact with solutions from a basic matrix, will be discussed beyond, as well as the general subject of vitriolization, and the important fact that a stable form of pyrite exists.

Marcasite.

Synonyms: radiated pyrites, white iron pyrites, cockscomb pyrites, pyrite blanche, pyrite rayonnée, strahlkies, speerkies, kamkies, leberkies, wasserkies, zellkies, binarkies, kirosite.

The published analyses of this mineral, and determinations of its density, are few, imperfect, and greatly scattered. It is believed that the best are presented below.

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[43] Ann. N. Y. Acad. Sci. (1877), I, 18.

[44] Proc. Am. Ass. Adv. Sci. (1882), XXXI, Pt. I, 271.

ANALYSES OF MARCASITE.

	Locality.	Analyst.	Fe.	S	Impurities	Sp. Gr.	Kind of Material.
1	Cornwall.	Hatchett. [45]	46.40	(53.60)		4.698	Radiated pyrites.
2	"	"	45.66	(54.34)		4.775	A smaller variety of radiated pyrites.
3	Locality unknown.	Berzelius. [46]	45.43	53.77	Si O^2, 0.80 ; Mn, 0.70.		Containing a very little iron-oxide.
4	Münsterthal, Baden.	Trapp. [47]	46.93	51.95			Speerkies.
5	Meggen, near Altenhunden.	"	43.55	47.50	Si O^2, 8.22 ; C, 0.32.		
6	Briccius mine, near Annaberg.	C. H. Scheidhauer. [48]	45.60	53.05	Cu, 1.41 ; As, 0.93.	4.729	Kirosite. H=7.5. S.G. by Breithaupt.
7	Wollin, on the coast of the Ostsee.	C. Rammelsberg. [49]	46.77	(53.23)		4.881	
8	Gross Allmerode, Hesse.	"	46.19	(53.81)		4.920 to 4.941	S.G. on coarsely powdered mineral.
9	Locality unknown.	Malaguti and Durocher. [50]	45.40	(54.60)		4.771	Radiated and globular.
10	" "	"	44.60	(55.40)		4.931	Compact.

[45] Phil. Trans. (1804), XCIV, 325.

[46] Mineralogie, p. 263, and Schweigg. Jour. (1819), XXVI, 67, and (1822) XXXVI, 311.

[47] Berg. u. hüttenm. Ztg. (1864), XXIII, 55.

[48] Pogg. Ann. (1843), LVIII, 281, and (1845), LXIV, 282.

[49] Zeitschr. d. geol. Ges. (1864), XVI, 268.

[50] Ann. d. Mines (1850), 4 Sér., XVII, 294.

Density of Marcasite.

Locality.	Analyst.	Sp. Gr.	Kind of Material.
Gross-Allmerode, Hesse.	F. Köhler,[51]	4.826 to 4.837	Common radiated masses, from the clay of the Brown Coal.
		4.845	Octahedra, all drusy.
		4.859 to 4.907	Octahedra, with smooth faces.
		4.879	Cubo-octahedra.
		4.919	Cubes.
Littmitz, Bohemia.	Breithaupt.[54]	4.847	
" "	C. Rammelsberg.[52]	4.878	Speerkies.
" "	Mohs.	4.857	
Joachimsthal.	C. Rammelsberg.[52]	4.865	
Schemnitz, Hungary.	G. Rose.[53]	4.848	Speerkies. S.G., at 11°.3 R.
" "	Breithaupt.[54]	4.878	
Freiberg.	"	4.601	
Derbyshire.	" [52]	4.879	Kamkies. S. G., at 12° R.

In considering these analyses, it is safe to say that no examination of massive, radiated or granular forms (strahlkies, speerkies, etc.), nor of paramorphs after pyrite, can be relied upon, as made upon pure material; for in all such instances there is a suspicion—often the visible evidence—of the intermixture of more or less pyrite, causing the extreme variations in density.

[51] Pogg. Ann. (1828), XIV, 91.

[52] Zeitschr. d. geol. Ges. (1864), XVI, 268.

[53] Pogg. Ann. (1849), LXXIV, 291.

[54] Erd. Jour. f. pr. Ch. (1835), IV, 257.

Only analyses and specific gravity determinations upon selected rhombic crystals of pure marcasite can have any definite value, and not a single investigation of that kind is on record ; most of the analysts have not specified the exact kind of material used, nor whether the density was determined on the coarse powder. So that we have yet no evidence of the absolute chemical composition of marcasite, except, of course, that it closely approximates that of pyrite ($Fe\ S^2$), nor of its exact density. For the latter, the average of all the figures above given is 4.847.

Weathering of Marcasite.

The phenomena of vitriolescence, *i. e.*, the development of copperas, are best displayed in the ordinary decomposition of this mineral.

Senft states, in regard to its alteration : "In moist air usually weathering very rapidly, and covering itself with an earthy or fibrous mould-like coating of copperas; but sometimes also becoming brown like pyrite, and then resisting the farther attack of moist air."[55]

According to Gmelin : "Most yellow iron pyrites, and likewise the white variety when well crystallized, remains unaltered in moist air."[56]

T. Egleston[57] refers to the ready oxidation of marcasite, and also confirms the last author in reference to a more durable form : "It decomposes very easily in the air, and forms sulphate of iron. In order to preserve it in collections, it must generally be coated with varnish. Sometimes, though rarely, the product of decomposition is hepatic pyrites, as is the case with the balls that occur in the chalk. A variety is sometimes found which does not decompose."

The alteration of marcasite into limonite, above referred to, has been observed in specimens from Upper Silesia, Derbyshire,

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[55] Die Krystall. Felsg., 140.

[56] Hand-book of Chem., V, 234.

[57] Lectures on Min. (1871), Pt. II, 123.

Scotland, etc.,[58] especially when nodules of the mineral are enveloped in clay.[59]

Marcasite is also subject to decomposition into hydrated iron-oxide, like pyrite, especially when protected from the atmosphere, as by envelopment in clay, etc.

Thus pseudomorphs in limonite after marcasite have been found in Bohemia, Hungary, the Orkney Islands, Scotland, etc.[60]

Senft has suggested that such pseudomorphs of iron-ochre, after pyrite and marcasite, may have been caused by a vitriolescence affected by solutions of alkaline carbonates, resulting in the alteration of the pyrites, atom by atom, into iron carbonate, afterwards converted by higher oxidation and loss of carbonic acid into iron-oxide.

One constituent of these limonite nodules, after marcasite or mixed pyrites, possesses great interest, viz., native iron, which has been detected in them, as small grains or scales, near Chotzen, Bohemia; near Muhlhausen; near Portrush, Scotland, and in California.[61]

Paragenesis of the Iron Pyrites.

During our consideration of the variations in density of the three forms of iron pyrites, reference has been made to the influence of included cavities, the work of oxidation, etc. But beyond the several agencies thus far alluded to, there is evidence of some other of universal prevalence, to account for these constant and wide variations. We need to go farther than the opinion generally accepted, and which has been thus expressed by v. Zepharovich, in regard to his own examination of the density of pyrite crystals, that "only when the intermixture of foreign particles occurs, or the pyrite crystals have suffered alteration, are the specific gravity figures modified."

The additional influence to which I refer is that exerted by the several natural iron sulphides upon each other, not merely by intermixtures and intercrystallizations, but either by iso-

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[58] Blum, Pseudomorphosen (1843), 197—199, and Nachtrag (1863), 185.

[59] Blum, *op. cit.*, Nachtrag (1847), 107—112.

[60] Roth, *op. cit.*, 105.

[61] *Idem*, 236.

morphous replacements in some cases, or by internal development through molecular re-arrangement. In order then to obtain a full appreciation of these effects upon the density, it appears desirable to consider the genetic relationship of the three species, their natural intermixtures and inter-crystallizations, and their isomorphous replacements.

As to the geognostic distribution of the varieties of pyrites, and an actual succession in their ordinary genetic history, some interesting facts may be recognized.

First, the development of iron sulphide within the mass of sedimentary deposits, at ordinary temperatures—it may be, chiefly as the very unstable protosulphide—has generally resulted in the first place,[62] in the production of scattered amorphous particles of pyrrhotite ("iron sulphide *in minimo*" of Stromeyer), with an excess of the metal and a varying but inferior amount of sulphur, compared with the proportions in the disulphide. In the magnetism of this product we may very probably find an indication which has favored both its development and its later concentration, by the electric currents which have always attended the consolidation, initial crystallization, chemical reactions, and metamorphism within sedimentary deposits. Another result appears to have been the combination of a small part of the sulphur at once in the form of $Fe\,S^2$. the greater part as $Fe\,S$, viz.:

$$Fe^5\,S^6 = 4\,Fe\,S + Fe\,S^2,$$
$$Fe^6\,S^7 = 5\,Fe\,S + Fe\,S^2,$$

etc., up to

$$Fe^{16}\,S^{17} = 15\,Fe\,S + Fe\,S^2.$$

In reference to the agent and reaction concerned in the development of natural sulphides, T. S. Hunt[63] has suggested:

"I have found that the unstable protosulphide which would naturally be first formed, may, under the influence of a persalt of iron, lose one half of its combined iron; and that from this reaction a stable bisulphide results. This subject of the origin of iron-pyrites is still under investigation."

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[62] Knop, N. Jahrb. f. Min. (1873), 521.

[63] Chem. and Geol. Essays (1875), 230.

But the observations of Breithaupt and Bischoff[64] point decidedly to quite another solvent, method of reaction, and significant product.

According to Breithaupt[65]: "it is not improbable that many iron-pyrites of the Freiberg lodes were once pyrrhotite. Pyrite is also always the more recent product, even where it occurs in association with pyrrhotite. . . Marcasite occurs also in hexagonal prisms, pseudomorphous after pyrrhotite, in part often and regularly intermixed with pyrite. . . The pseudomorphs after pyrrhotite exhibit almost throughout a contraction of volume," indicated by abundant cavities which are occupied by crystals of pyrite, quartz, and other minerals. In Wunsiedel, the pyrrhotite was observed to pass into pyrite with a diminution of bulk. Roth[66] remarks that "in the alteration of pyrrhotite into pyrite, a part of the iron is removed. Breithaupt observed that on the larger pseudomorphs of the kind in Freiberg, carbonate of iron occurred, partly with other carbonates containing iron-protoxide. Calcite and quartz are other abundant associates."

Bischoff states:

"The lodes near Freiberg not infrequently contain pseudomorphs of iron pyrites after magnetic pyrites, though the latter mineral occurs but very rarely. Wherever the two minerals are associated, the iron pyrites is always the more recent of the two; and probably much of the iron pyrites in lodes was originally magnetic pyrites.

"In the conversion of magnetic pyrites into iron pyrites a portion of the iron would be removed; and, consistently with this, it appears that in the neighborhood of Freiberg, where this alteration has taken place very extensively, the magnetic pyrites has furnished material for the production of iron-spar and other minerals containing protoxide of iron. Therefore the iron has been extracted from magnetic pyrites by the action of carbonated water. In this alteration the magnetic pyrites must lose 25.54 per cent. of iron; and, since the density of iron pyrites is greater than that of magnetic pyrites, the volume of the former would

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[64] Chem. and Phys. Geol. (1859), III, 455–456.

[65] Paragenesis, pp. 130, 161–164 170.

[66] *Op. cit.*, I, 242.

amount to only 68 per cent. of the latter. The pseudomorphs do almost always indicate a reduction of volume. . . . Since magnetic pyrites is most frequently amorphous, the iron pyrites resulting from it would present its own crystalline form, so that there would not be any indication of the change that might have taken place."

So too in regard to eruptive rocks, in all the fresh basalts examined by E. Bořický,[67] the pyritous particles consisted of pyrrhotite, while, in those basalts which had been weathered and altered, pyrite crystals took its place.

It must be added, however, that with other conditions, even at ordinary temperatures, the highest sulphide combination, $Fe\ S^2$, pyrite, has sometimes been formed at once in the presence of an excess of hydrogen-sulphide ; *e. g.*, in the well-known observation of Forchhammer,[68] at a running spring on the seashore, where the ferruginous water was borne into a mass of decomposing sea-weed ; also, in one instance, in the mud at the bottom of a pond.[69]

So too, in thermal waters, pyrite appears to have been, and to be now, the original deposit ; *e. g.*, in the highly crystalline and exceedingly pyritiferous lodes of Colorado, etc., and the deposit from warm springs at Aix la Chapelle, Burgbrohl, etc., and, in the form of brass-yellow crystalline globules, in the sand and the Roman brickwork, at Bourbonne, France.[70]

Secondly, in the course of metamorphism of the rock, and usually in proportion to its degree, the scattered particles of pyrrhotite, usually $Fe^7\ S^8$ or $6\ Fe\ S + Fe\ S^2$, have suffered a further alteration—it may be by the common solvent, carbonic acid—by which the entire amount of sulphur was combined as $Fe\ S^2$, and the excess—over one quarter—of the amount of iron was transported elsewhere. The new combination, $Fe\ S^2$, was most commonly effected under certain conditions—probably great pressure and high temperature—which resulted in the

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67 Petrog. Stud. Bas.-gest. Böhmens (1873), 36, 258–259.

68 Rep. Brit. Ass. Adv. Sci.

69 Gmelin-Kraut, Handb. d. Chem., 6th ed., III, 333.

70 A. Daubrée, Études syn. de Géol. expér. (1879), 89.

form of pyrite. An example of this has already been given in the reference to Freiberg.

However, under other conditions of alteration—I suspect, low pressure and ordinary temperature of surface waters, and it may be, as Mène suggests, under conditions of chemical double decomposition—the iron disulphide, derived from the original pyrrhotite, has at once assumed the form of marcasite. The common occurrence of this mineral in calcareous beds, *e. g.*, the chalk of England, the Trenton limestone of New York, the carboniferous limestones of Wisconsin and Illinois, etc., suggests the possibility that the presence of calcium carbonate, under certain conditions, may determine the crystallization of iron disulphide as marcasite, rather than pyrite, in a way similar to that of the crystallization of calcium carbonate as aragonite, rather than calcite, in the presence of strontium carbonate, gypsum, or salts of lead, as shown by Credner.

A reference is here called for to the view advanced by Breithaupt,[71] who endeavored to account for the origin of the different physical properties of the two dimorphous minerals, pyrite and marcasite, by connecting them with those of the dimorphous forms of sulphur itself, first ascertained by Mitscherlich. But later investigation has even reversed the analogy attributed by Breithaupt to some of the physical properties of the sulphur forms, *e. g.*, that of specific gravity; and little remains except that the form S*a*, *i. e.*, of native sulphur, and marcasite both happen to be ortho-rhombic and homœomorphous.

Thirdly, by some process not yet understood, pyrite is often transformed afterwards into its dimorphous associate, marcasite. A discrimination of this kind has been recently made by Prof. A. Liversidge,[72] between iron pyrites of primary and secondary metamorphic origin, in his description of the occurrence of concretions of pyrites at a mine, near Rydal, in New South Wales. Here, he states, the pyrite was originally crystallized in cubes through a slaty shale, afterward dissolved and redeposited "in the form of nodules of marcasite, *i. e.*, the rhombic and less

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[71] Erd. Jour. f. pr. Chem. (1835), IV, 257.

[72] Jour. and Proc. of Royal Soc. of New So. Wales (1884), XVIII, 47.

durable form of iron pyrites." He also states that the "pyrites of the nodules oxidizes with great rapidity; specimens kept for only a few months rapidly fall to powder, and become incrusted with crystals of iron-sulphate."

Distribution of the Iron Pyrites.

We may sum up the general distribution of the three minerals as follows:

Pyrrhotite is comparatively of uncommon occurrence and limited abundance, and generally more or less mixed with the other pyrites. It is found in eruptive rocks, *e. g.*, most basalts; also in many granites, diorites, and serpentines; but mainly in clay slates, mica slates, and rocks of incipient metamorphism, *e. g.*, in beds of limestone which have plainly escaped the alteration into marble prevailing in adjacent districts.

Marcasite constitutes largely or altogether the pyrites occupying thin seams and coatings in the Coal-beds, lignitic shales, the dolomytes of Saxony and Cornwall, the Chalk, many limestones of America, and, in general, the unaltered sedimentary rocks, such as sandstones, graywacke schists, peat, clay, bituminous coals, casts of fossils, and also veins of galenite.

Pyrite has a far wider distribution, from its stability, but nevertheless tends to predominate in the crystalline rocks, largely constituted of magnesia- and iron-micas, hornblende, chlorite, and serpentine, such as dioryte, chlorite- and hornblende-schists, etc. It is prominent as well in weathered eruptive rocks and most granites, marbles, argillytes, the scattered particles in anthracite, and nearly all metalliferous veins, *e. g.*, the sulphuret lodes of Colorado.

In clay-beds, the pyritous nodules generally consist of successive crusts or transition mixtures of this and the preceding mineral, as in the clays of Schoharie, N. Y., and Amboy, N. J.

The distribution of the three pyrites along the Appalachian chain presents points of interest, in view of the great series of extensive pyritous deposits which are scattered along, from Alabama through the Carolinas, Virginia, Pennsylvania, New York, and New England, into Newfoundland.

The association of the pyrites at the principal localities is about as follows:

Locality.	Kind of Pyrites.	Rock-Matrix.
Ducktown, Tenn.	Pyrrhotite, with a little chalcopyrite.	Veins in mica slate.
Sevier and Cocke Co., Tenn.	Pyrite, passing into alum and alunogen.	Argillyte of the "alum caves."
Greensboro, N.C., and the Piedmont region of N. C.	Pyrite, brilliant and auriferous, with chalcopyrite	Veins in granitoid gneisses and in diorytes.
Ore Knob, N. C.	Pyrrhotite, with a little pyrite and chalcopyrite.	Vein in hornblende-schist.
Richmond, Va.	Pyrite and marcasite.	Coal and associated shales.
Louisa Co., Va.	Pyrite, partly decomposed, and chalcopyrite.	
Baltimore, Md.	Pyrite and chalcopyrite.	Limestone, slate, etc.
Chester Co,, Pa.	Pyrite.	
Radnor, Pa.	Pyrite in brilliant cubes.	Slaty limestone.
Lancaster, Pa.	Pyrite in cubes.	
Gap Mine Lancaster Co., Pa.	Pyrrhotite and nickeliferous pyrite.	
Cornwall, Lebanon Co., Pa.	Pyrite, cobaltiferous, in lustrous cubo-octahedra, and chalcopyrite.	
Pottstown, n'r French Creek, Pa.	Pyrite, in brilliant octahedra.	Magnetite and calcite vein.
Mahanoy City, Pa.	Pyrite, in dull octahedra.	Bituminous coal and associated shales.
Scranton, Pa.	Pyrite.	Anthracite and associated slates.
Hurdstown, Morris Co., N. J.	Pyrrhotite.	
Franklin, N. J.	Arsenopyrite.	Granular limestone.
Perth Amboy, N. J.	Pyrite in radiated nodules.	Cretaceous clays.
Jersey City and Weehawken, N. J.	Pyrite in brilliant, smooth octahedra, with a little chalcopyrite.	Calcite veins in dykes of Mesozoic diabase.
New York Island.	Pyrite in bright octahedra and granular flakes, efflorescing into alum; also chalcopyrite and marcasite.	Gneiss and mica-schist.
Westchester Co., N.Y.	Pyrite, pyrrhotite, and chalcopyrite.	Granular limestone.
Cortlandt, N. Y.	Pyrite and pyrrhotite.	Granite, dioryte, etc.
Edenville, Orange Co., N. Y.	Arsenopyrite and pyrrhotite.	Granular limestone.

Locality.	Kind of Pyrites.	Rock-Matrix.
Monroe, Orange Co., N. Y.	Pyrrhotite and pyrite	Granular limestone.
Warwick, Orange Co., N. Y.	Pyrite and marcasite.	Granite.
Anthony's Nose, N. Y.	Pyrrhotite, with pyrite.	Vein in Laurentian granite and hornblendyte.
Kent, Putnam Co., N. Y.	Arsenopyrite.	
Phillipstown, N. Y.	Marcasite.	Magnesian limestone.
Jefferson Co., N. Y.	Marcasite, in drusy flakes.	Trenton limestone.
Orange and Milford, Ct.	Pyrite in cubes.	Chlorite slate.
Trumbull and Monroe, Ct.	Marcasite, arsenopyrite, pyrite in octahedra, and pyrrhotite.	
Stafford, Ct.	Pyrite, efflorescing into alum and copperas.	Mica slate.
Roxbury, Ct.	Pyrite and arsenopyrite.	
Canaan, Ct.	Pyrite, decomposing into iron-ochre.	Marble, hydro-mica slate, and mica schist.
Sheffield, Mass.	Pyrite, efflorescing into alum, and chalcopyrite.	White marble.
Great Barrington, Mass.	Pyrite, in brilliant cubes and grains, sometimes assuming a coppery tarnish.	Blue-gray dolomyte.
Stockbridge, Mass.	{ Pyrite. { Pyrite and pyrrhotite.	Limestone. Hydro-mica slate.
Lee, Mass.	Pyrite in minute modified cubes, quickly decomposing to iron-ochre.	White magnesian marble.
Cummington, Mass., and, in general, Western New England.	Marcasite, massive and fibrous.	Mica-slate.
Charlemont, Mass.	Pyrrhotite and pyrite.	Vein in gneiss.
Rowe, Mass.	Pyrite.	
Fairhaven, Vt.	Pyrite,	Roofing-slate.
Sutherland Falls, Vt.	Pyrite, in small fine-grained bunches.	Argillaceous bands in white marble.
Thetford, Vt.	Pyrrhotite.	
Vernon, Vt.	Pyrite.	Roofing-slate.
Vershire, Vt.	Pyrite, chalcopyrite, and arsenopyrite.	

Locality.	Kind of Pyrites.	Rock-Matrix.
Shoreham, Vt.	Pyrite.	Limestone and black marble.
Stafford, Corinth and Shrewsbury, Vt.	Pyrrhotite, chalcopyrite, and pyrite.	
Brookfield, Waterbury and Stockbridge, Vt.	Arsenopyrite, pyrite, and chalcopyrite.	
Nova Scotia.	Pyrite, arsenopyrite, and chalcopyrite.	Quartz veins in slate.
Albert, N. B.	Pyrite nodules, inclined to ready decay.	Carboniferous sandstone.
Notre Dame Bay, Newfoundland.	Pyrite and chalcopyrite.	Slate.
Elizabethtown, Ont., Can.	Pyrite, with a little pyrrhotite.	Laurentian quartzyte and gneiss.
Lennoxville, Q., Can.	Pyrite.	
Lachute, Q., Can.	Pyrrhotite.	Laurentian crystalline limestone.

A consideration of the facts above presented renders it very probable that in most of these instances the original condition of the iron sulphide, along the Appalachian belt, has been that of pyrrhotite, which now, as a rule, survives only in the belts of less crystalline schists, especially mica-slates, and in the larger beds and veins; that its conversion into marcasite and pyrite, (and other pyritous minerals, in the presence of Cu, Ni, As, etc.) has generally attended the progress of the metamorphism of the enclosing rocks; that, as in Europe, the surplus of iron, separated in the transformation of $Fe^7 S^8$ into $Fe S^2$, has been removed by carbonated waters and re-deposited in the form of iron-carbonate within the interstices and larger cavities of limestone, excavated by the same solvent, through interchange for calcium carbonate, and over the natural subterranean drainage-planes afforded by beds of gneiss and mica-slate; that some of these ferruginous deposits may have been later converted into hematite and magnetite, by local metamorphism, and that subsequent oxidation of all these deposits, partial or complete, still going on, has been at least an important source of the limonite ores along the Appalachians.

Doubtless the origin of the limonite-deposits has been due to several causes, and we can hardly question, for example, their direct derivation in many cases, by oxidation, from ancient beds of pyrites, as claimed by Hunt and Prime[73], and even of such beds *in situ*, as held by Shepard and Percival, *e. g.*, when the two materials lie in contact, as in Carroll County, Virginia.[74] etc.

More recently, another theory has been advanced by J. D. Dana[75] to account for these iron-ores, which may be briefly presented in the following quotations:

"But the nearly total absence from the ore of sulphur (seldom over one-tenth of a per-cent.) appears to be evidence that pyrite played a very subordinate part in the production of limonite. It is a question of interest, whether the iron was in the state of carbonate when the deposits were originally made by sedimentary action, or, whether in some different state, from which it was converted into carbonate as one of the results of metamorphism."

He apparently inclines to believe that it has been caused by drainage deposits of iron carried into the marshes as carbonate, a "result no doubt favored by the excess of carbonic acid in the Lower Silurian atmosphere and waters," this action having taken place during some epoch of long-continued marshes during which the schists were laid down.

In a more recent "note on the making of limonite ore beds,"[76] Prof. Dana states the view he is disposed to favor as to the origin of the irregular ferriferous areas in the limestone formation, as follows:

"The stratigraphical change, in the region, from limestone to slate, indicates that a change took place in the era of their formation from limestone-making seas to mud-distributing seas. During the transition from one to the other, iron was washed down from not distant land, in the state of bicarbonate or a salt of an organic acid, over limited areas of the calcareous deposits. These areas, so invaded by the iron solution, during the transition-epoch, were within interior seas or basins, or marshes, half shut off from the ocean. The calcare-

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[73] Trans. Am. Inst. Min. Eng. (1874–75), III, 410.

[74] *Idem* (1876–77), V, 82.

[75] Am. Jour. Sci. (1877), 3, XIV, 139.

[76] *Idem* (1884), 3, XXVIII, 398.

ous material, wherever receiving the iron-bearing waters, became changed more or less completely to ferriferous limestone or ferriferous dolomite, or received pure iron-carbonate," etc.

This theory appears to me incomplete, in that it does not account for two important facts: first the destination of the vast quantity of iron which was separated and transported *somewhere*, during the metamorphism of the schists and the alteration of the greater part of their contained pyrrhotite into the higher sulphides. The whole mass of the Appalachians is so saturated with pyrites, that the slight divergence of the line of heavier deposits of limonite from that of the concentrated bodies of pyrites in Western New England—to which Prof. Dana calls attention—seems to have little bearing on the main question. For such a comparison, in my view, the kind of pyrites should be distinguished; and it is worthy of attention that the more abundant limonite-deposits are not in the vicinity of pyrrhotite lodes (*e. g.*, Strafford, Gap Mine, Ore Knob, and Ducktown), but of masses of rock saturated by pyrite—as well as other iron minerals, of course—and of the pyrite lodes, *e. g.*, the limonite beds at Brandon, Salisbury, Amenia, Kittany Valley, etc., or even underlaid by pyrites, *e. g.*, in Louisa County, Va.[77]

Secondly, the improbability of the preservation down to this day of any large bodies whatever of so unstable an ore as siderite, intercalated in strata so long exposed to sub-aerial atmospheric action, seems inconsistent with the ancient origin involved in Prof. Dana's theory of its contemporaneous deposition. In my view, the ferruginous marsh-deposits of that distant period may be represented by the present pyritous "lodes," pyritiferous schists and limestones, and crystalline iron-oxides; the concentration of the siderites and the saturation of beds by iron-carbonate attended the long subsequent metamorphism of those sediments; and the limonites, pipe-ores, etc., have owed their development to oxidation, still in progress, throughout the uplifted terrane of crystalline rocks, during the comparatively recent though very long subsequent period.

Intermixtures of the Iron Pyrites.

These intermixtures are now known to be very common, and

[77] Trans. Am. Inst. Min. Eng. (1876–7), 529.

indeed always more or less represented in any locality in which these minerals abound. Some of the first distinct observations of this fact were thus recorded by Stromeyer, in the study of certain pyrrhotite ores :

"The magnetic pyrites of Fichtelberg and Breitenbrunn were so intimately intermixed with pyrite that it was impossible to separate it from them." [78]

He also observed a similar intimate intergrowth at other localities, in the following per-centage proportions:

	Pyrrhotite.	*Pyrite.*
Treseburg, Hartz Mts., - -	96.08	3.92
Barèges, Upper Pyrenees, - -	75.58	24.42

Since the proportion of the pyrite in these magnetic pyrites was found very constant, and the fragments employed for analysis had been previously purified from all visibly intermixed pyrite with the utmost care, with the assistance of a magnifying glass, Stromeyer considered it very probable that this pyrite was not mechanically intermixed with the magnetic pyrites, but occurred chemically dissolved in it, and that the considerable quantity of the same in the magnetic pyrite of the Pyrenees accounted for its feeble magnetism.

This view, however, was at once controverted by Berzelius,[79] who found that on slicing and polishing the same magnetic pyrites, the intermixed pyrite was seen crossing it, with different color and hardness, and was therefore not dissolved in it.

A similarly intermixed growth of these two minerals, or the enclosure of crystals of one within the other, has been observed by G. Rose.[80]

Kenngott[81] later called attention to a like intergrowth in a specimen of pyrite, associated with marcasite, from Tavistock, Devonshire. In this it was evident that these dimorphous species had crystallized simultaneously ; both were well intermixed, and even intergrown in the same crystal, plates of one often intersected the crystals of the other, and minute or drusy crystals

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[78] Gilb. Ann. (1814), XLVIII, 186 and 163.
[79] Gilb. Ann. (1814), XLVIII, 209.
[80] Reise nach dem Ural, II, 117 ; Pogg. Ann. (1849), LXXIV, 293.
[81] Sitzungsb. k. Akad. Wiss. in Wien (1853), X, 293 (Min. Notiz., No. 2).

of one were implanted or encrusted upon the other. Wöhler came to the same conclusion of the simultaneous formation of the two minerals.

Zippe[82] has discovered pseudomorphs of mixed pyrite and marcasite, after red and black silver ore, at Joachimsthal, in Bohemia, in which "sometimes the same pseudomorphs consist partly of iron pyrites and partly of radiated pyrites;" the same association was observed by A. Stelzner in pseudomorphs after silver-glance, near Brand, in Saxony.[83]

Displacement pseudomorphs also occur among these three forms of iron pyrites:

Marcasite after pyrite, in cubes which are paramorphs, in plastic clays of Liebnitz, Bohemia,[84] and near Freiberg.[85]

Marcasite after pyrrhotite, in hexagonal prisms, near Freiberg, Stranitza, Dognatzka, etc.,[86] and at Loben near St. Leonhard in Carinthia.[87]

Pyrite after marcasite, as a paramorph, at Rodna,[88] Transylvania, in the form of the well known double twin crystal of the latter mineral, but made up of an aggregate of minute cubes and pentagonal dodecahedra of the former.

Pyrite after pyrrhotite,, near Freiberg,[89] Himmelsfürst, Wunsiedel, etc.

It is significant that in no case has pyrrhotite ever been found as a pseudomorph after either of the other two pyrites.

Our view of the part constantly played by the iron pyrites, in isomorphous replacement, yet needs a brief reference to their arrangement in the complex constitution of many other metallic sulphides, as shown by Rammelsberg and Dana. In the table below, some of the more simple and prominent are gathered together; but the intermediate proportions, either of mere mechan-

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82 Blum, *op. cit.* (1843), 300–304.
83 Berg. u. Hütt. Zeit., XXVIII, No. 10, 83.
84 Blum, *op. cit.*, Nachtrag (1847), 149–151.
85 Roth, *op. cit.*, I, 110.
86 *Idem*, 242.
87 J. Rumpf, Verh. d. K. K. geol. Reichs. (1870), No. 1, 2–3.
88 Sillem, Jahrb. f. Min. (1851), 399.
89 Paragenesis, Breithaupt, 130.

ical intermixture or of chemical combination, are exceedingly varied. In regard to the usual composition of chalcopyrite, for example, Dana states that "some analyses give other proportions, but probably from mixture with pyrite. These are indefinite mixtures of the two, and with the increase of the latter the color becomes paler. . . In Cornwall, . . its richness may in general be judged of by the color; if of a fine yellow hue, and readily yielding to the hammer, it may be considered a good ore; but if hard and pale yellow, it is poor from admixture with pyrite." Taking then as materials the simple arsenide and the protosulphide of iron, and the four minerals, pyrite ($Fe\ S^2$. S.G.=5.), marcasite ($Fe\ S^2$. S.G.=4.85), chalcocite ($Cu^2\ S$. S.G.=5.7), and löllingite ($Fe\ As^2$. S.G.=8.6), the constitution of the minerals mentioned in the first column is found to present the replacements stated in the last.

Mineral.	Sp. Gr	Formula.	Molecular Constitution.
Leucopyrite.	7.1	$Fe\ As + Fe\ As^2$	1 iron arsenide + 1 löllingite.
Arsenopyrite.	6.0	$Fe\ As^2 + Fe\ S^2$	1 löllingite + 1 pyrite.
Pacite.	6.3	$4\ Fe\ As^2 + Fe\ S^2$	4 löllingite + 1 pyrite.
Lonchidite.	4.9	$Fe\ As^2 + Fe\ S^2 +$ 23 to 25 $Fe\ S^2$	1 arsenopyrite + 23 to 25 marcasite.
Bornite, Killarney.		$Fe\ S + 2\ Cu^2\ S$	1 iron monosulphide + 2 chalcocite.
" Corsica.		$Cu^2\ S + Fe\ S^2$	1 chalcocite + 1 pyrite.
" Cornwall.		$4\ (Cu^2, Fe)\ S + Fe\ S^2$	4 bornite + 1 pyrite.
" Bristol, Ct.		$6\ (Cu^2, Fe)\ S + Fe\ S^2$	6 bornite + 1 pyrite.
" Lauterberg		$10\ (Cu^2, Fe)\ S + Fe\ S^2$	10 bornite + 1 pyrite.
" Ramos, Mex.	5.2	$11\ (Cu^2, Fe)\ S + Fe\ S^2$	11 bornite + 1 pyrite.
Chalcopyrite.	4.2	$Cu^2\ S + Fe\ S + Fe\ S^2$	1 bornite + 1 pyrite.
Cubanite,	4.1	$Cu^2\ S + Fe\ S + 3\ Fe\ S^2$	1 chalcopyrite + 2 pyrite.
Barnhardtite.	4.5	$2\ Cu^2\ S + Fe\ S + Fe\ S^2$	1 chalcopyrite + 1 chalcocite.

LIST OF SPECIMENS EXAMINED OF APLODONTIA MAJOR.

No.	Source.	Sex.	Locality.	Date.	Collector.	Nature of Specimen.
2101/1501	Mus. C. H. M.	♂ ad.	Placer Co., California,	Oct. 7, 1885	Chas. A. Allen.	Skeleton and skin.
2102/1502	"	♀	"	" 8, "	"	Skull " "
2103/1503	"	♂	"	" 9, "	"	" " "
2104/1504	"	♀	"	" 9, "	"	" " "
2105/1505	"	♂	"	" 12, "	"	Skeleton " "
2106/1506	"	♂ ad.	"	" 15, "	"	" " "
2107/1507	"	♀ ad.	"	" 16, "	"	" " "
2108/1508	"	♀ ad.	"	" 17, "	"	Skull " "

LIST OF SPECIMENS EXAMINED OF APLODONTIA RUFA.

No.	Source.	Sex.	Locality.	Date.	Collector.	Nature of Specimen.
278	U. S. Nat. Mus.		F't Steilacoom, W. T.	1854	Dr. Geo. Suckley.	Old skin.
2476	"		" "		" "	Skull.
3891	"	♂ ad.	Puget's Sound.		Dr. T. R. Peale.	"
3942/4047	"	♂ ad.	" "		" "	Skull and mounted skin.
22203/13781	"	im.	Coos Co., Oregon.	May 5, 1883	Todd, Alva & Abbott.	Skull and skin.
22204/15356	"	"	" "	" "	" " "	" "
22205	"	♂ ad.	Olympia, W. T.		E. C. Wingard.	Mounted skeleton.
11355	"		" "		" "	Skin in alcohol.
11357	"		" "		" "	" "
22146	"		(No data.)			Skull.
12592	"		Coquille, Oregon.		Dr. F. S. Matteson.	Skin.
12846	"	♂	(No data.)			"
13186	"	♀	Clackamas Co., Oreg.	1878	J. K. Lum.	"
1130/693	Mus. C. H. M.	♂ im.	Seattle, Wash. Ter.	Dec. 14, 1883	O. B. Johnson.	Skull and skin.

EXPLANATION OF PLATES.

(ALL NATURAL SIZE.)

PLATE XIX.—SKULL OF APLODONTIA MAJOR ♂ AD., No. 2101 Mus. C. H. M.

a. cranium from above; *b.* cranium from below; *c.* mandible from below.

Drawn by Ernest E. T. Seton.

PLATE XX.—COMPARATIVE VIEW OF SKULLS OF APLODONTIA MAJOR AND APLODONTIA RUFA.

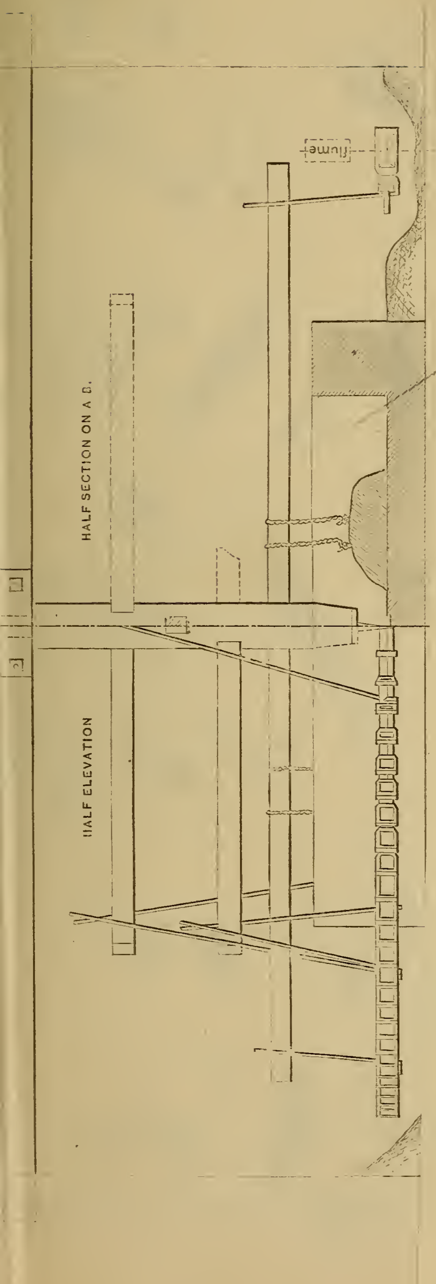
a. & *b.* *A. major* ♂ ad., No. 2106 Mus. C. H. M. *a.* from above; *b.* occipital plane.

c. & *d.* *A. rufa* ♂ ad., No. 22205 U. S. Nat. Mus. *c.* from above; *d.* occipital plane.

a. & *c.* drawn by Miss Villette Anderson; *b.* & *d.* by Dr. Geo. Marx.

FIGURE 1, page 327, SKULL OF APLODONTIA MAJOR ♀ AD. No. 2107 Mus. C. H. M. Showing persistent fronto-premaxillary suture.

Drawn by Miss Lillie Sullivan.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HALF SECTION ON A B.
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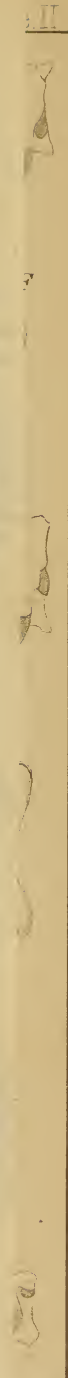
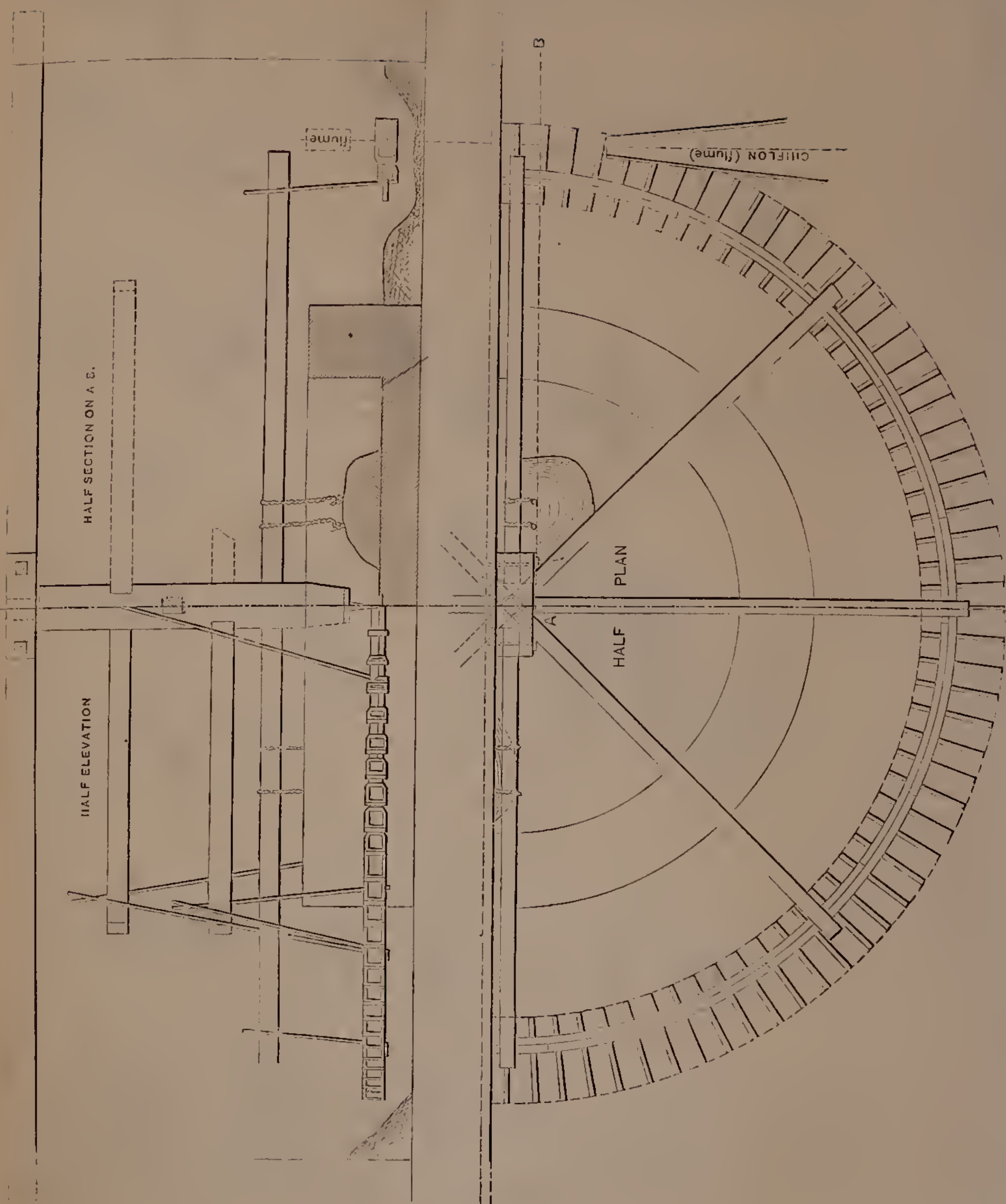
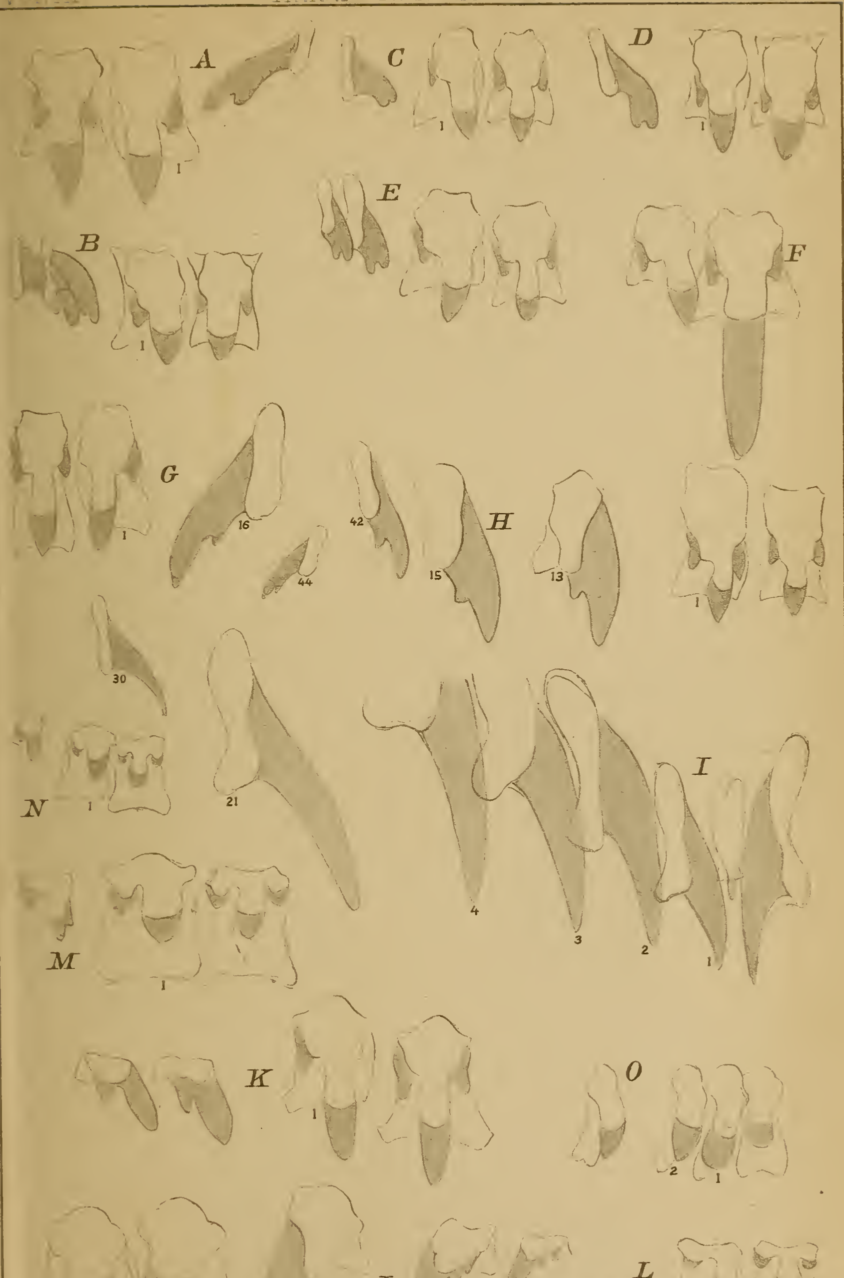




TAHONA (Spoon Arrastre)
Scale 50:1



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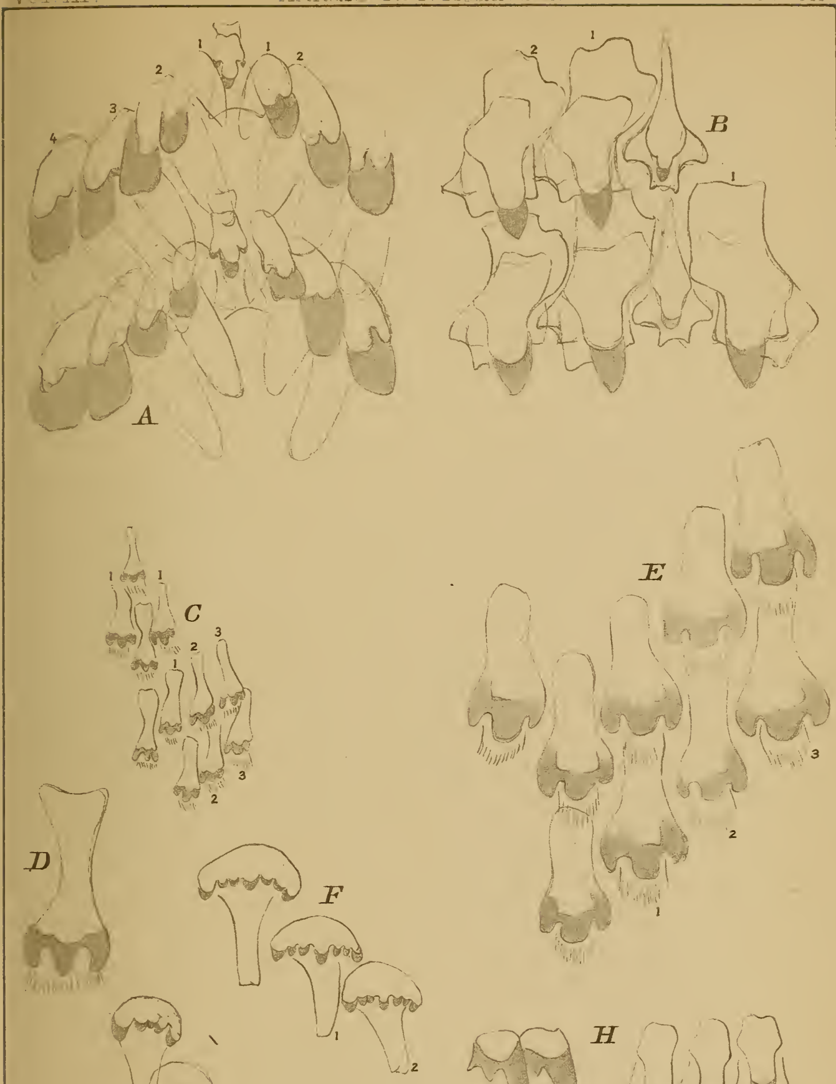

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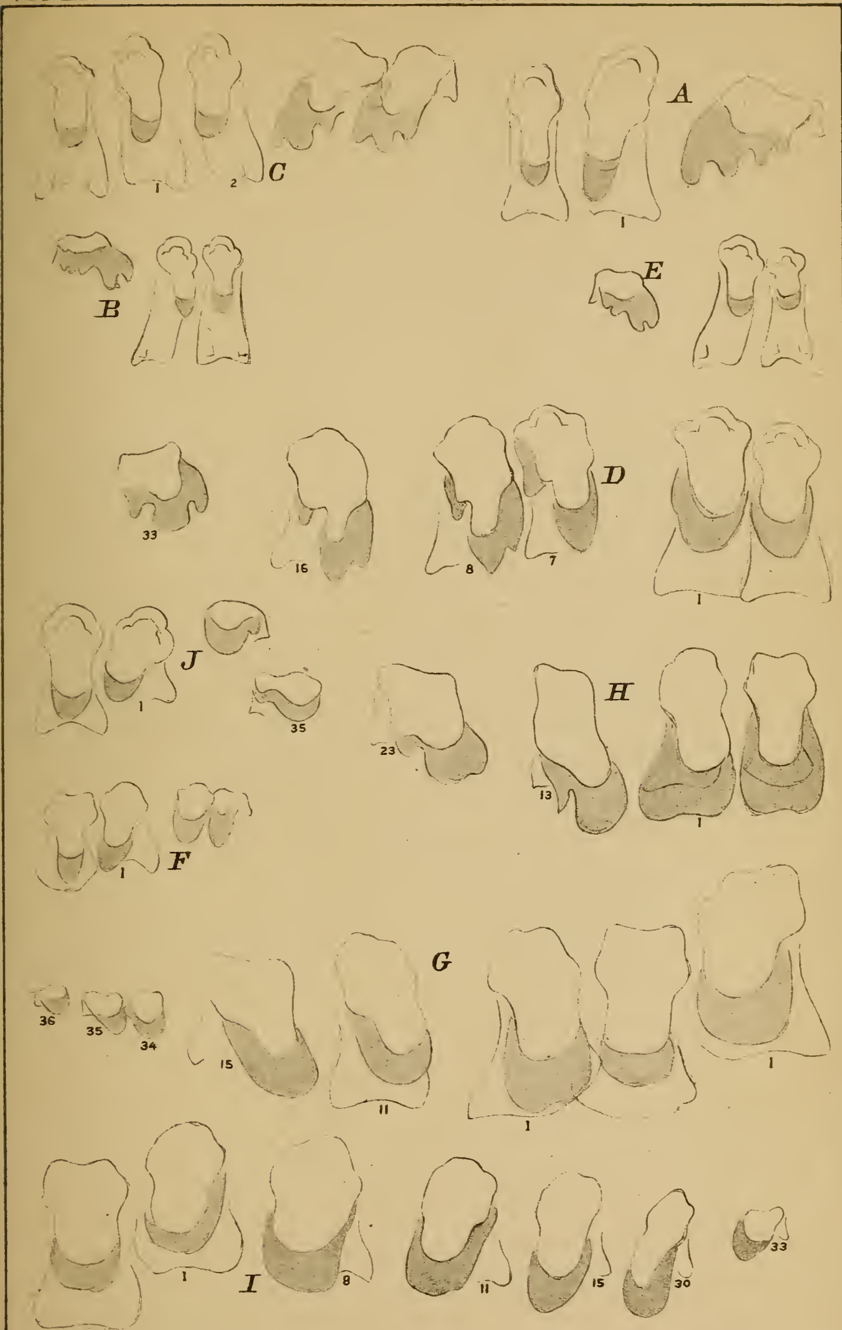

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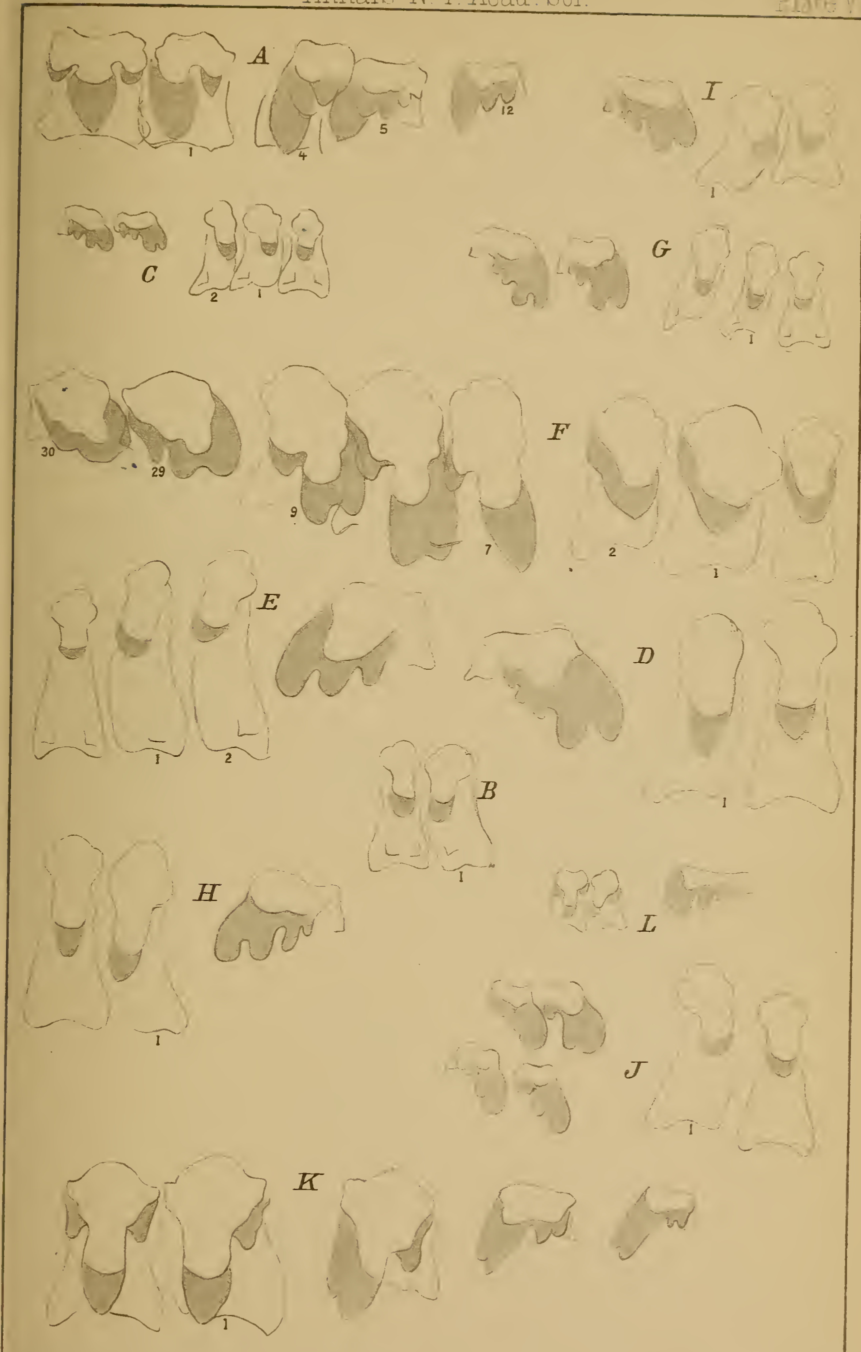

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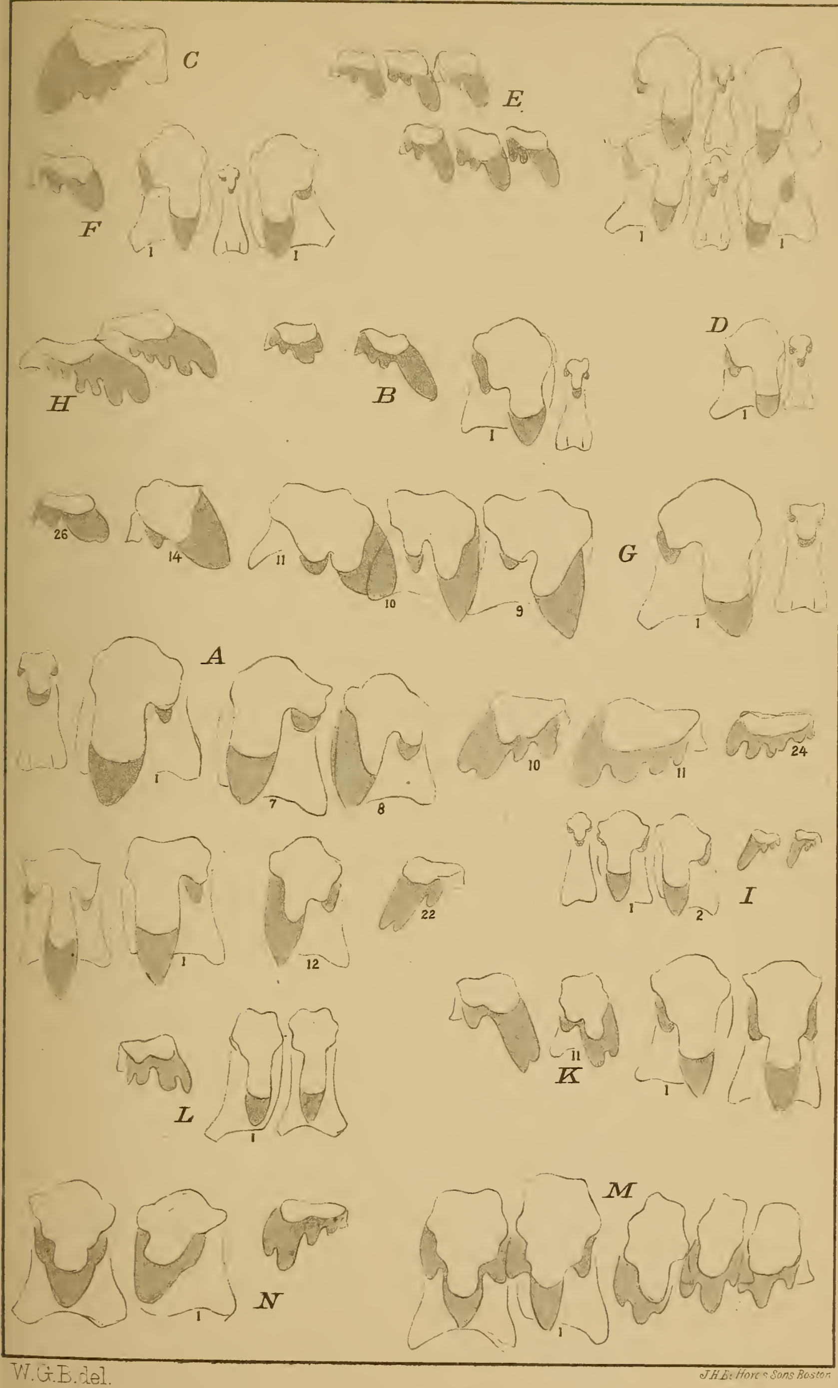

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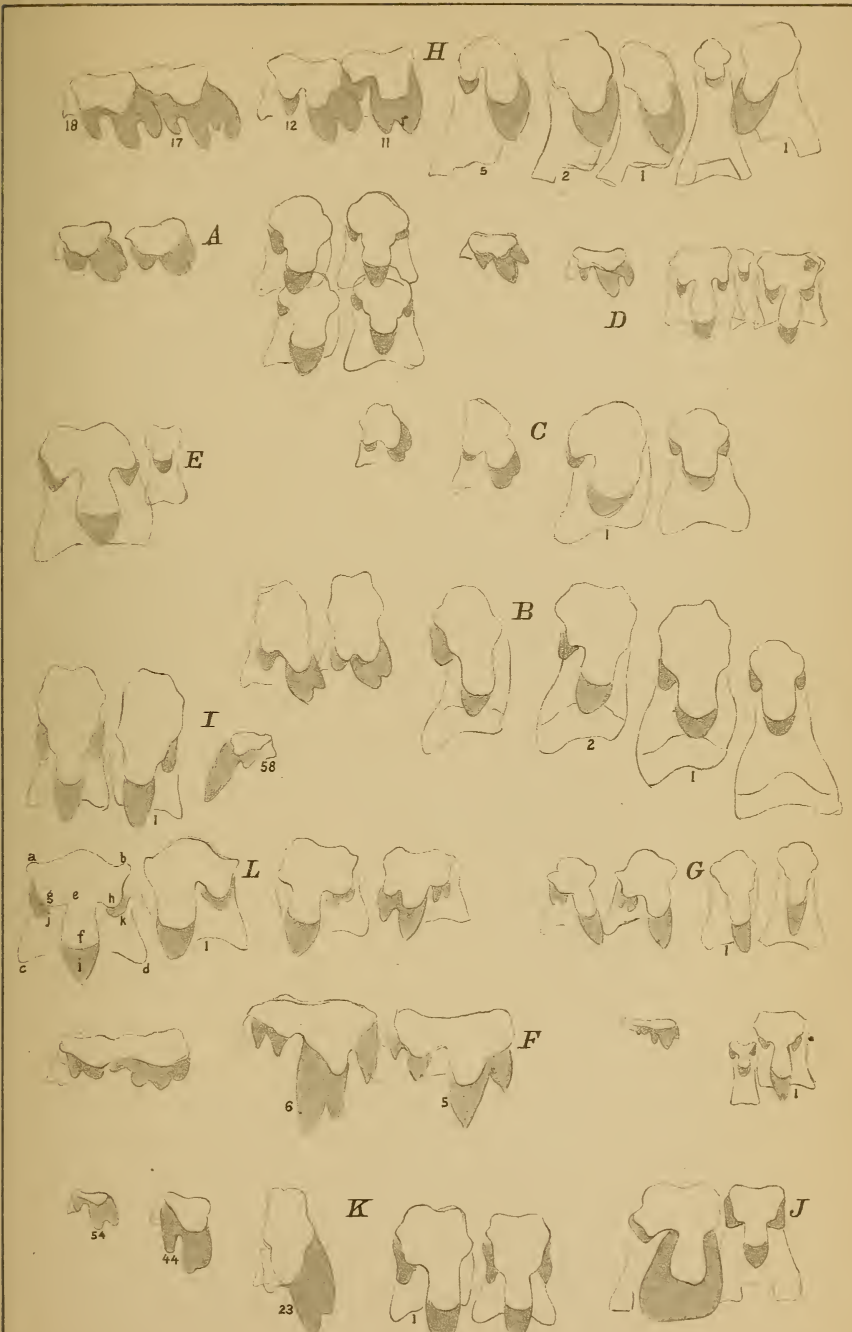

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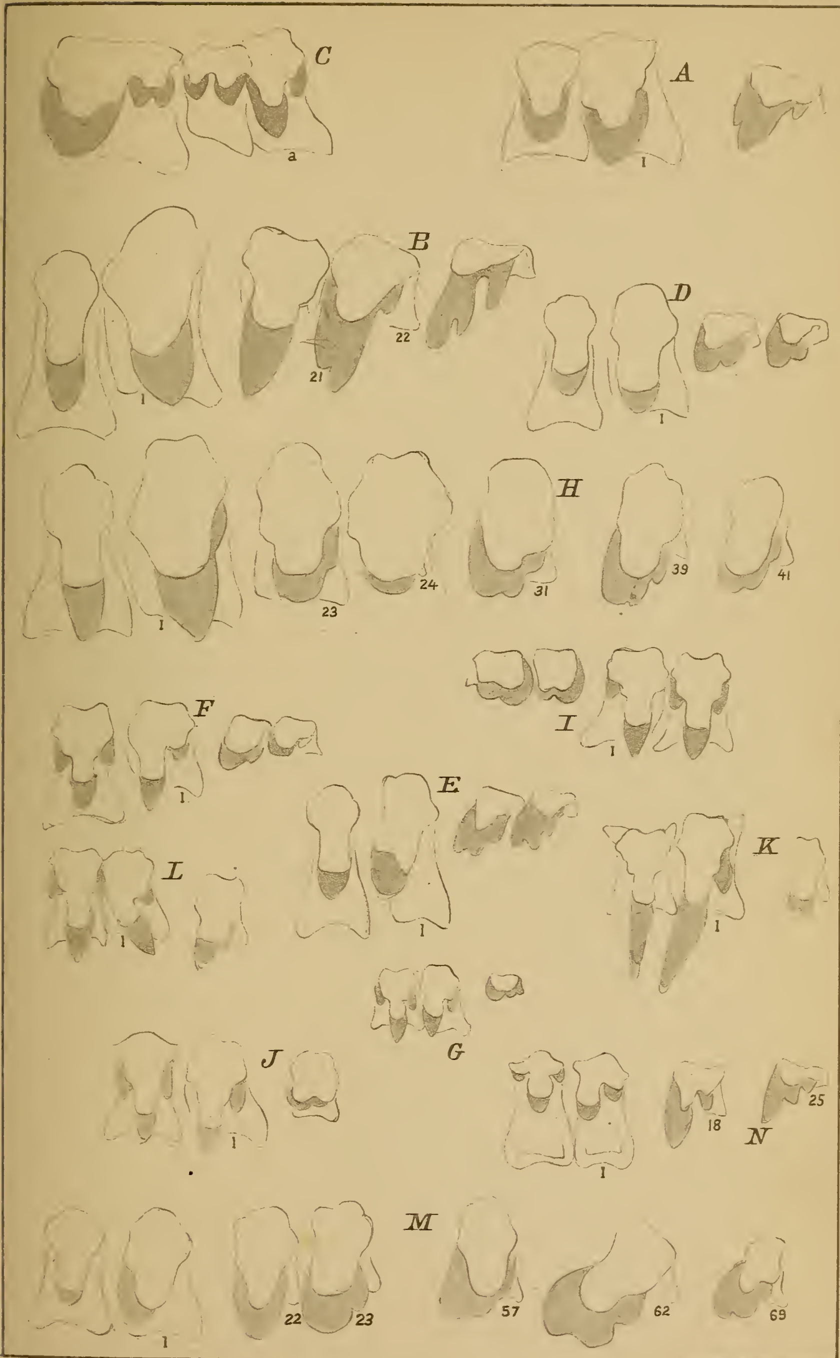
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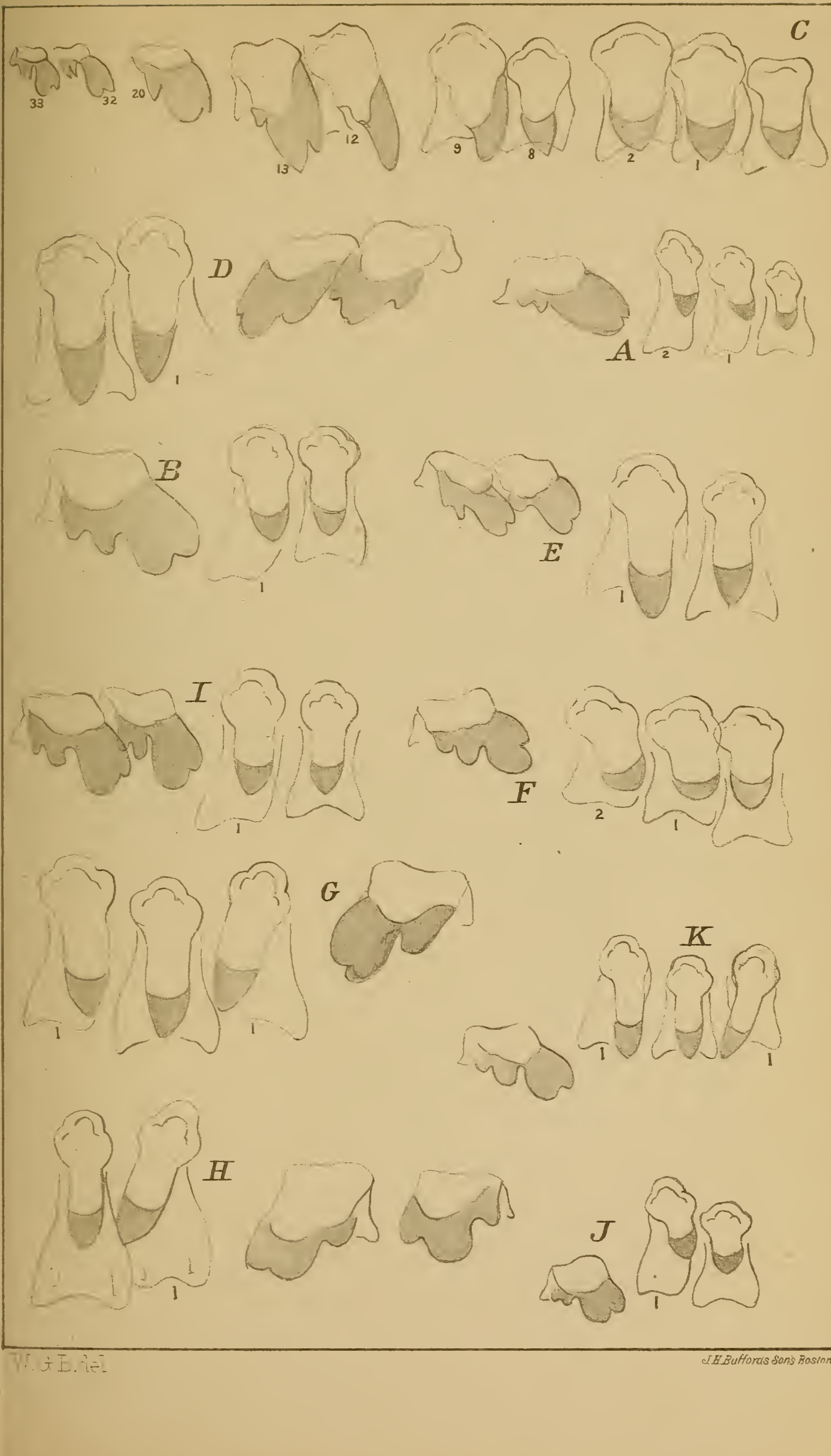

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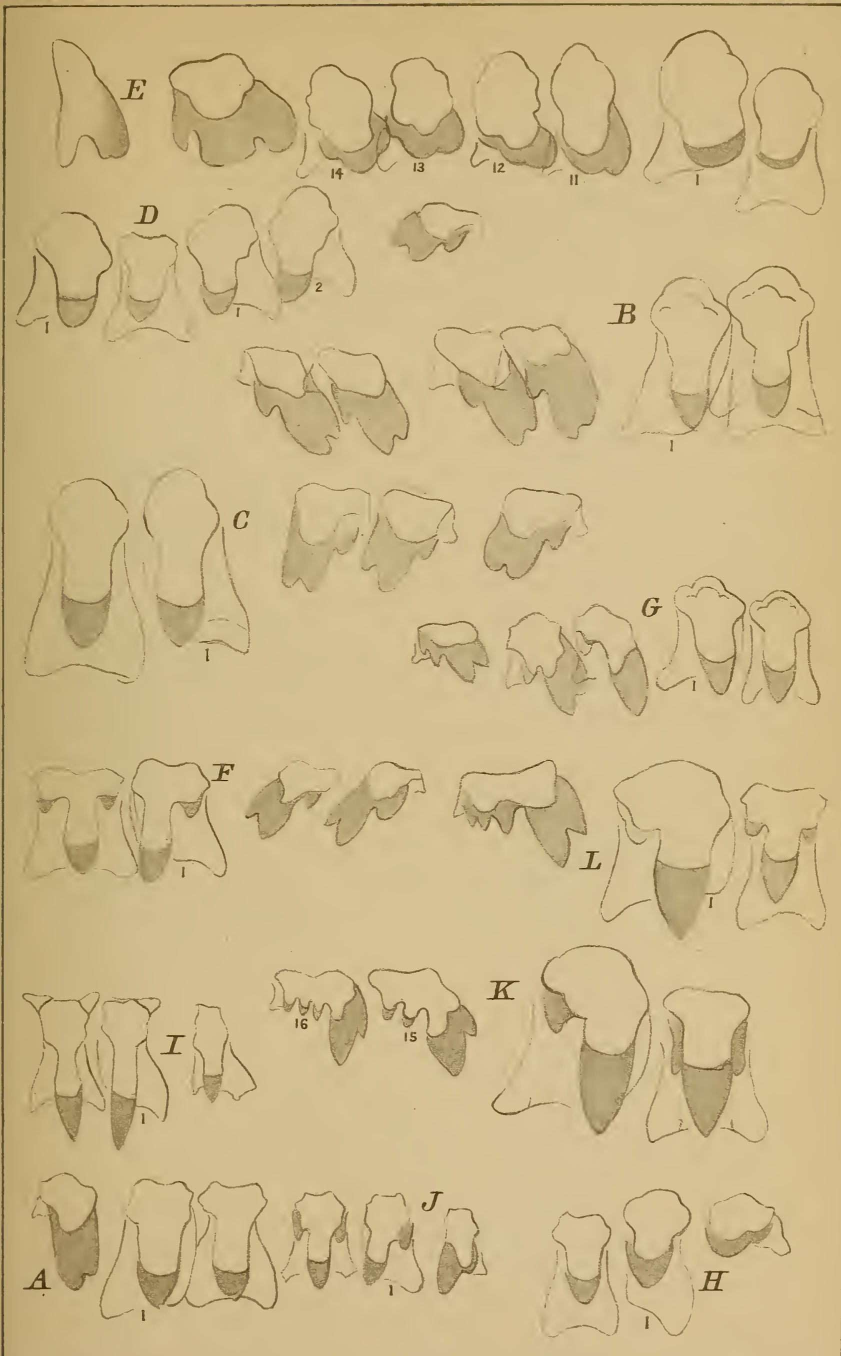

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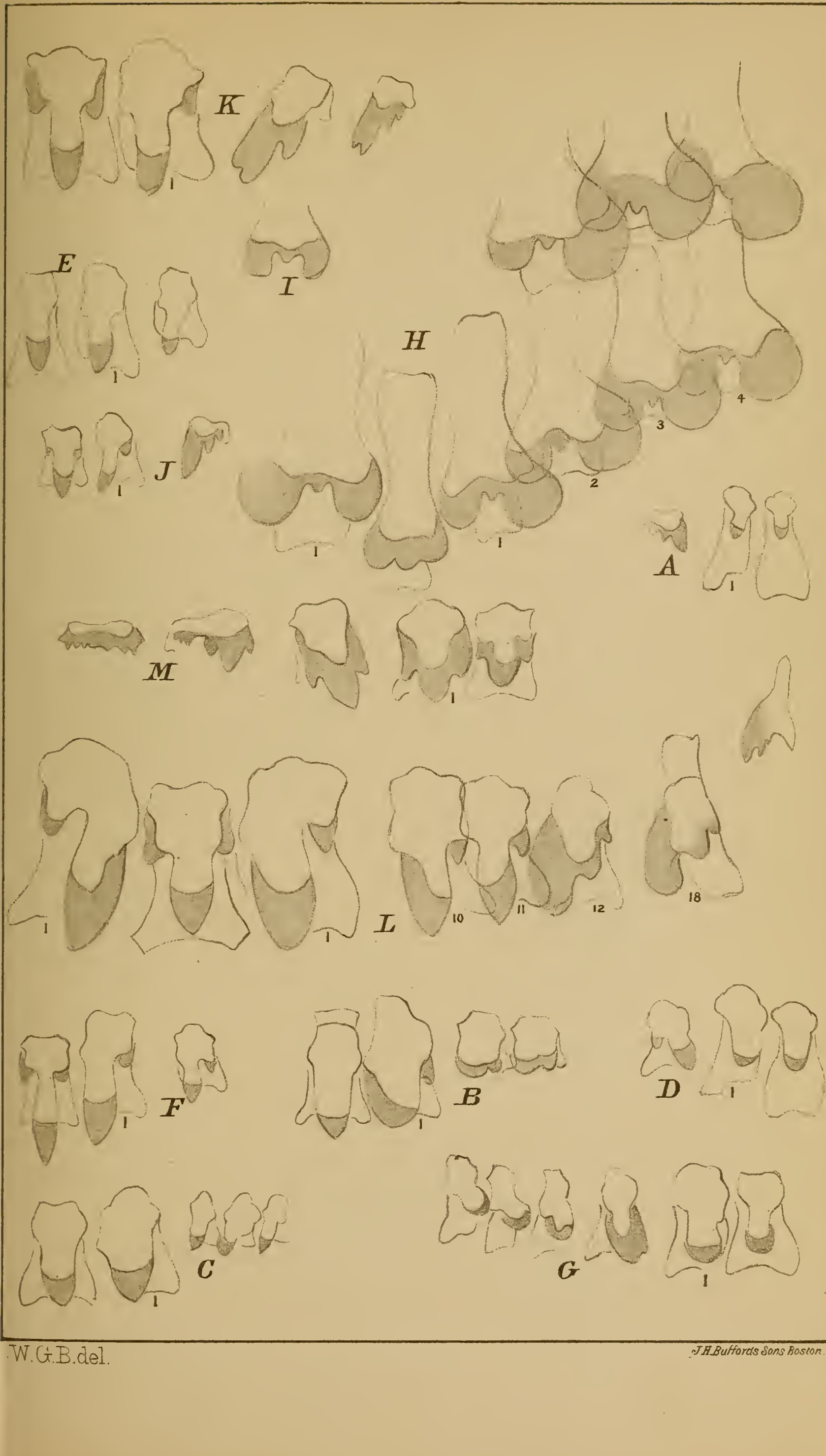

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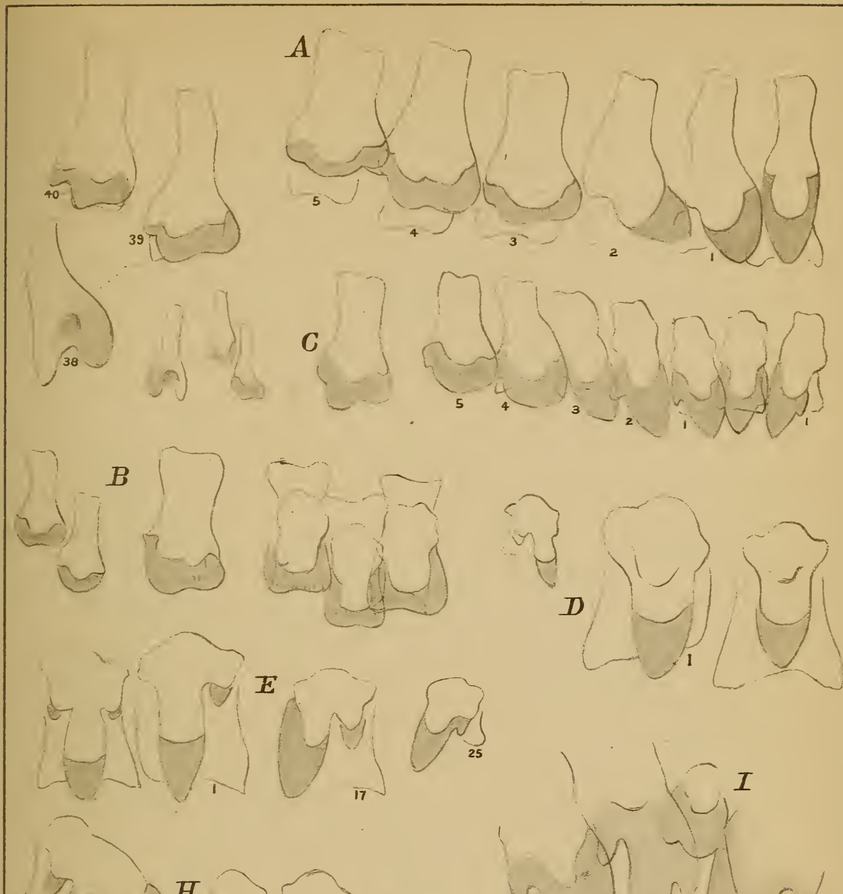

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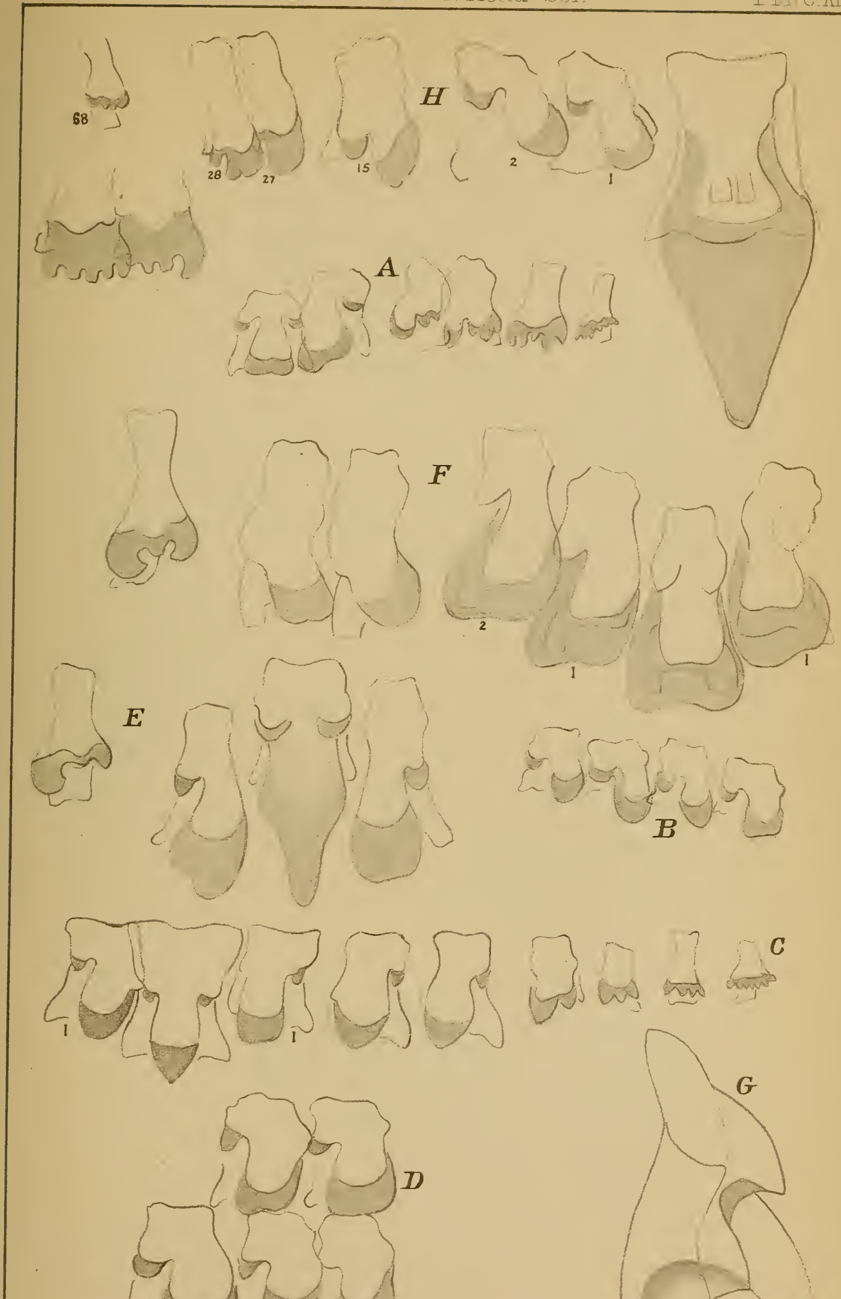

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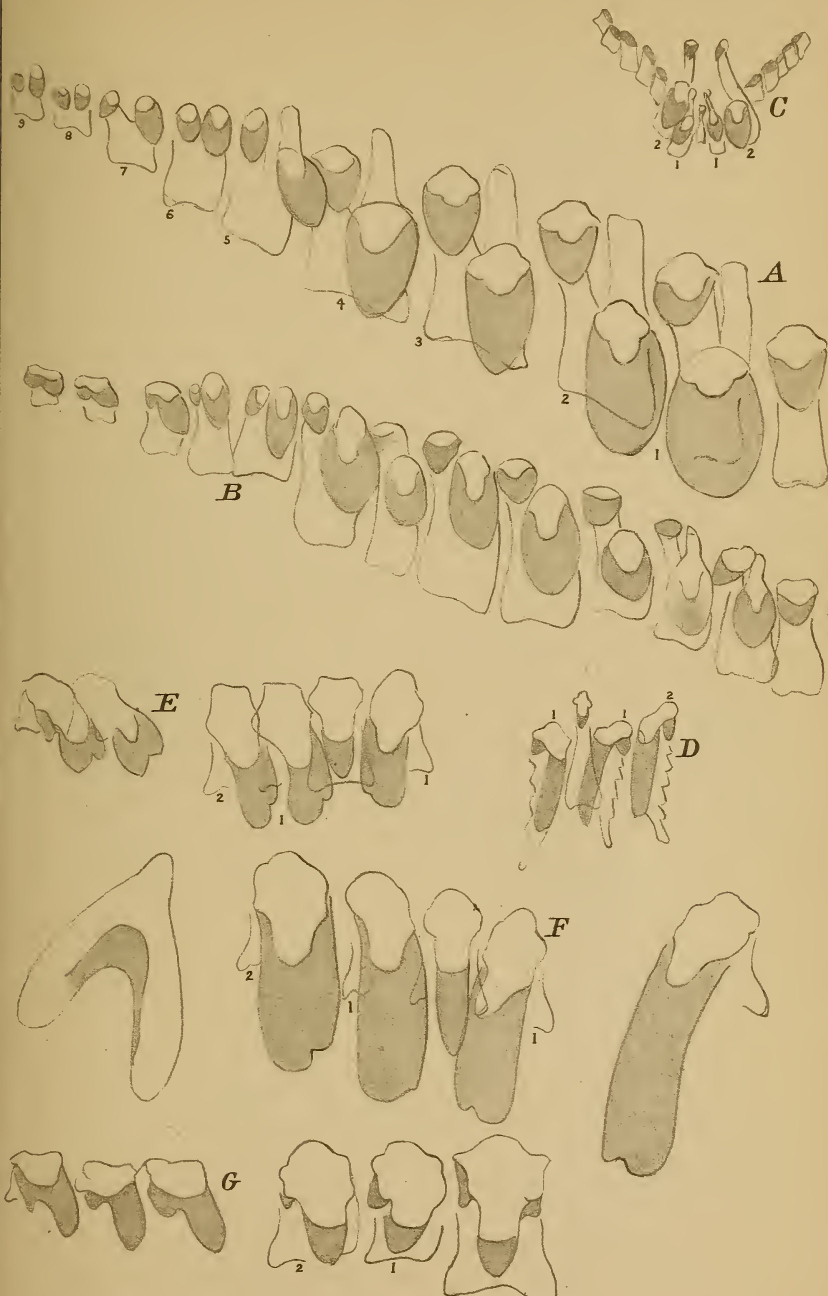

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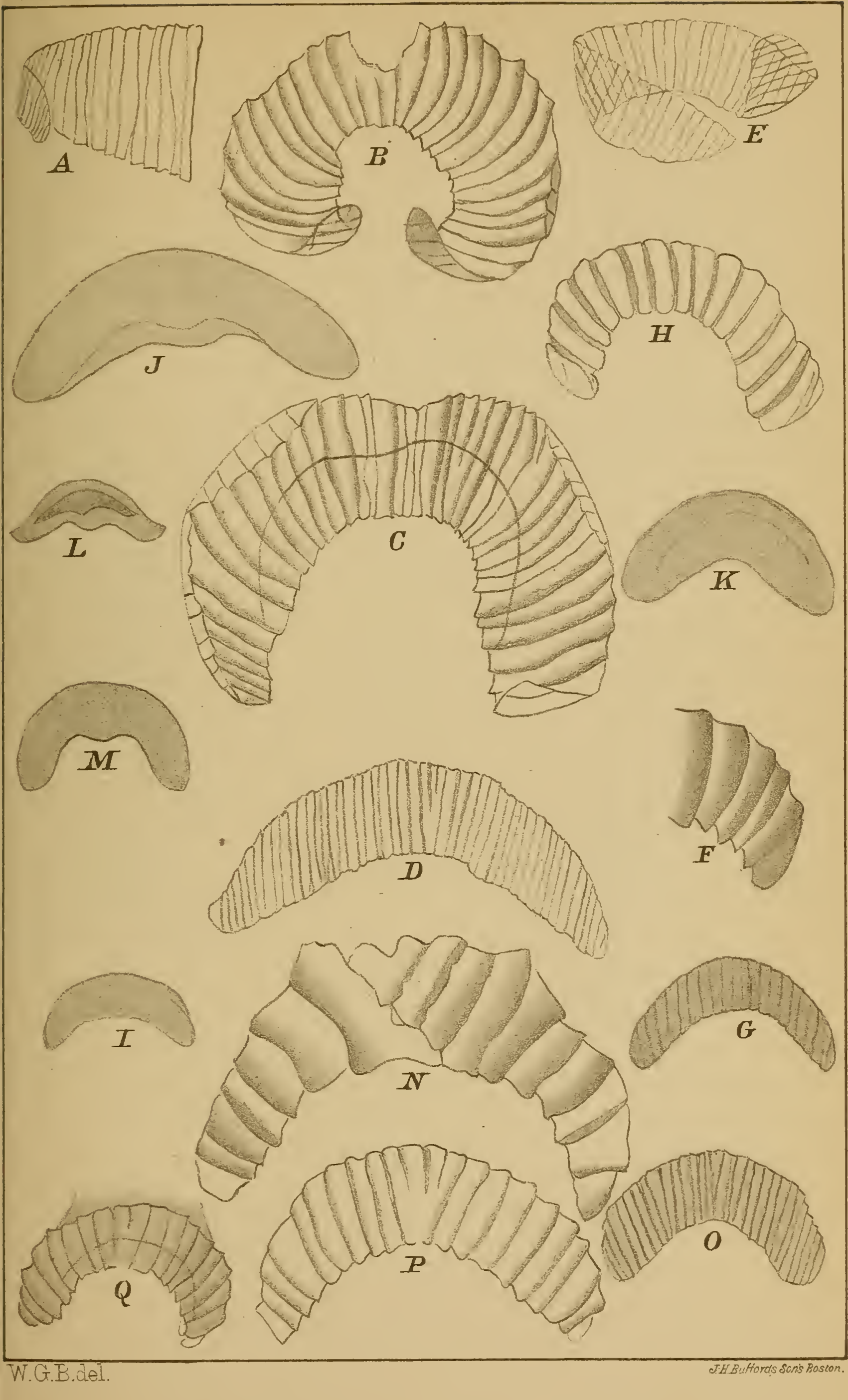

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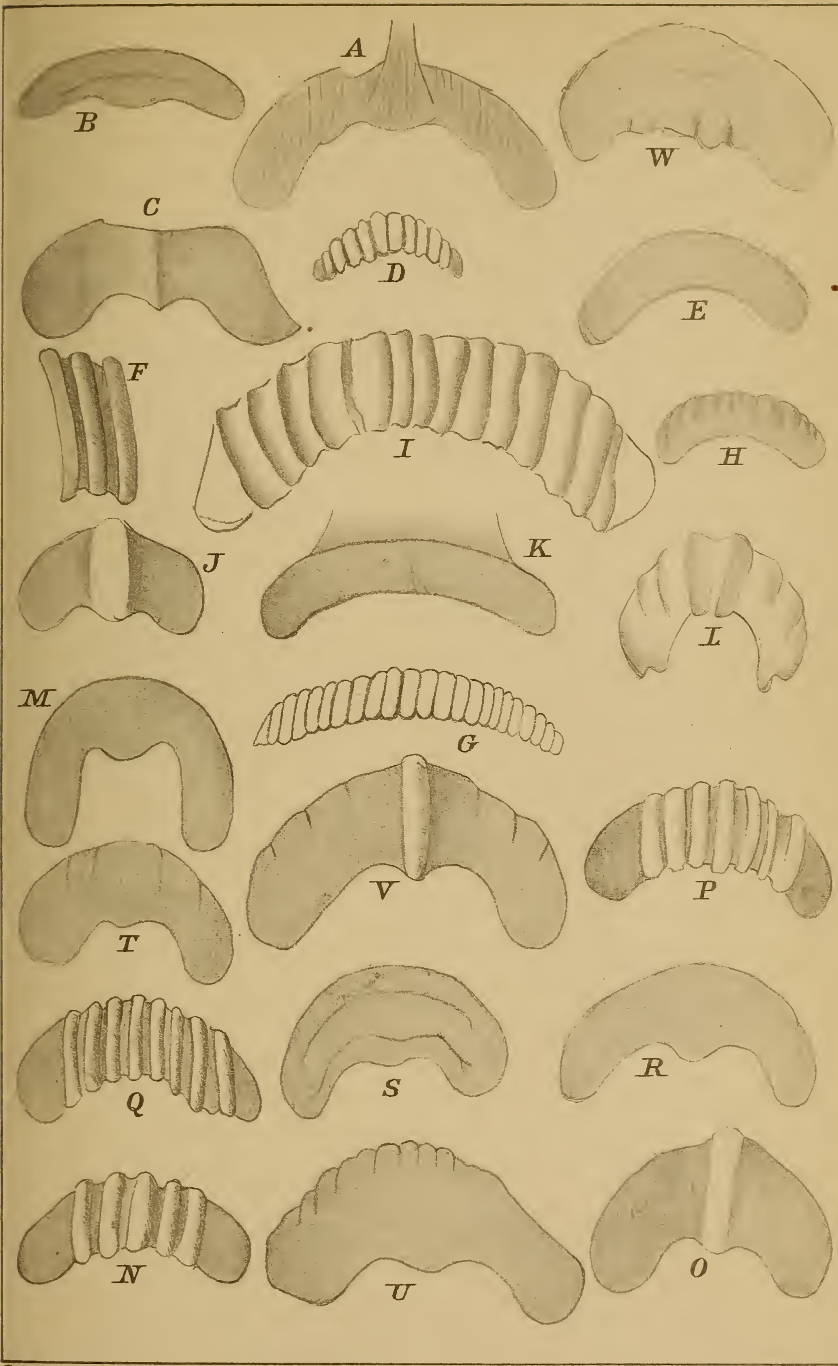

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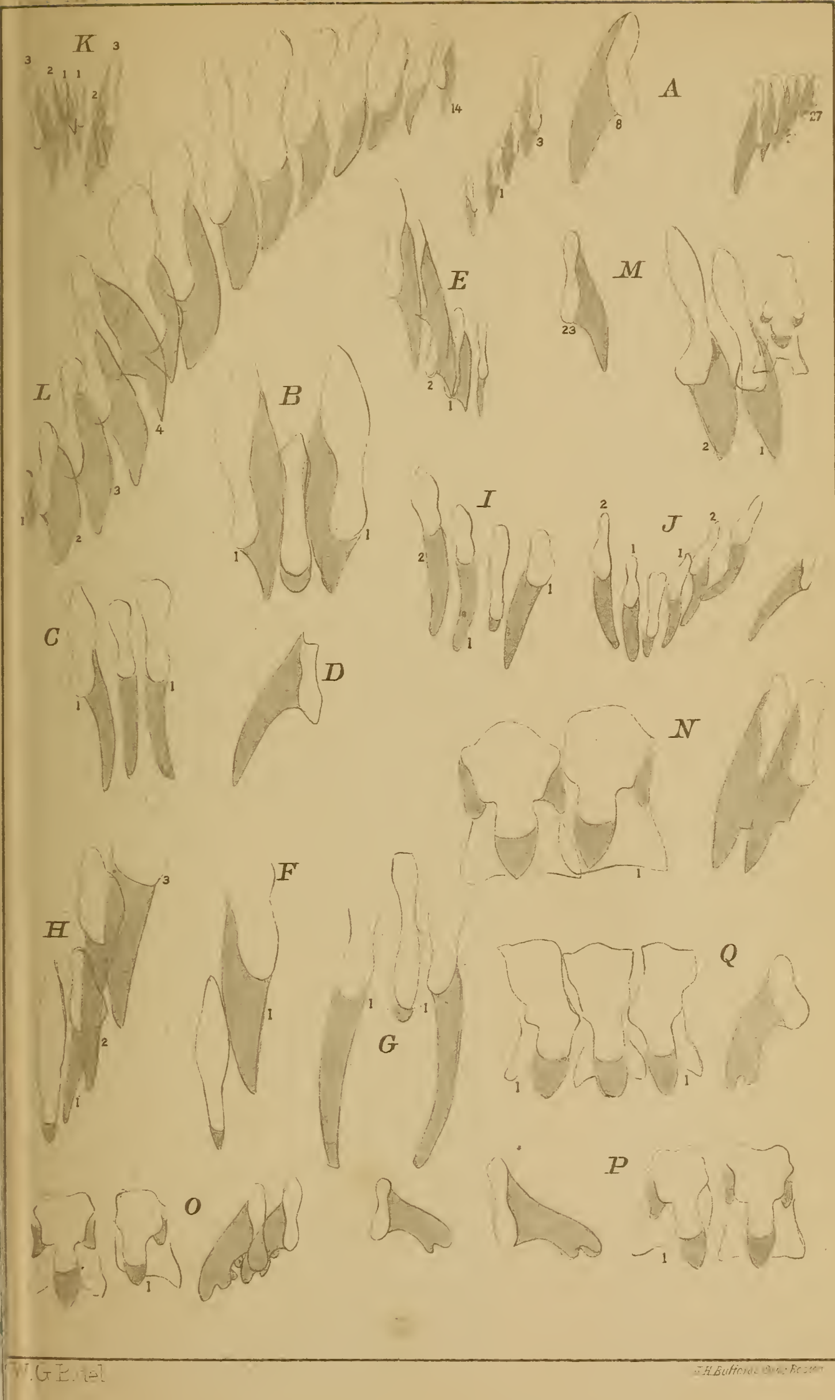

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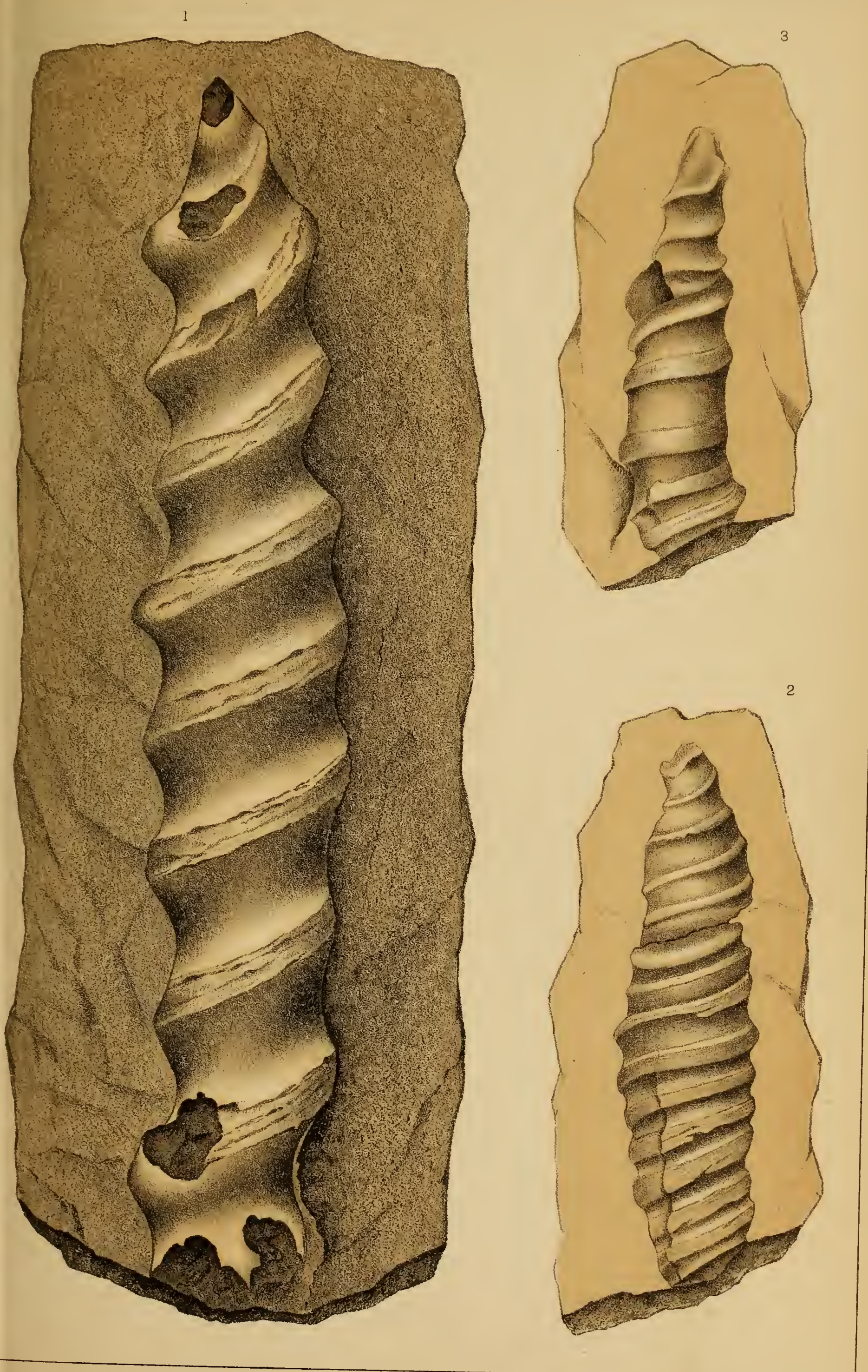
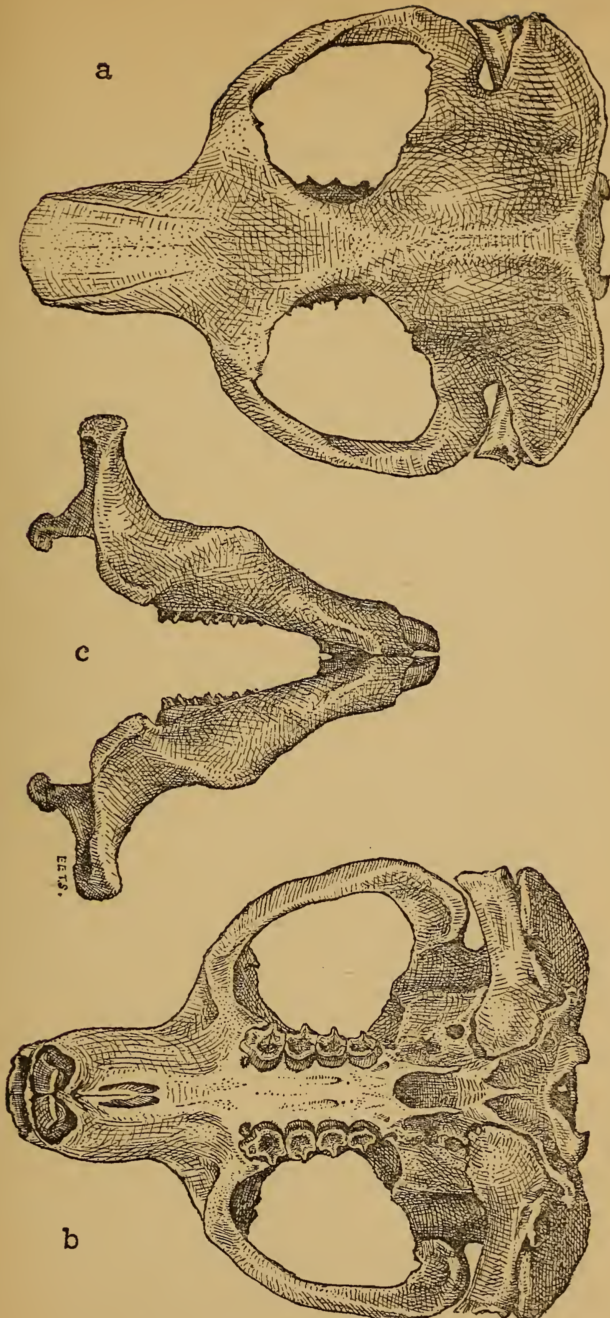
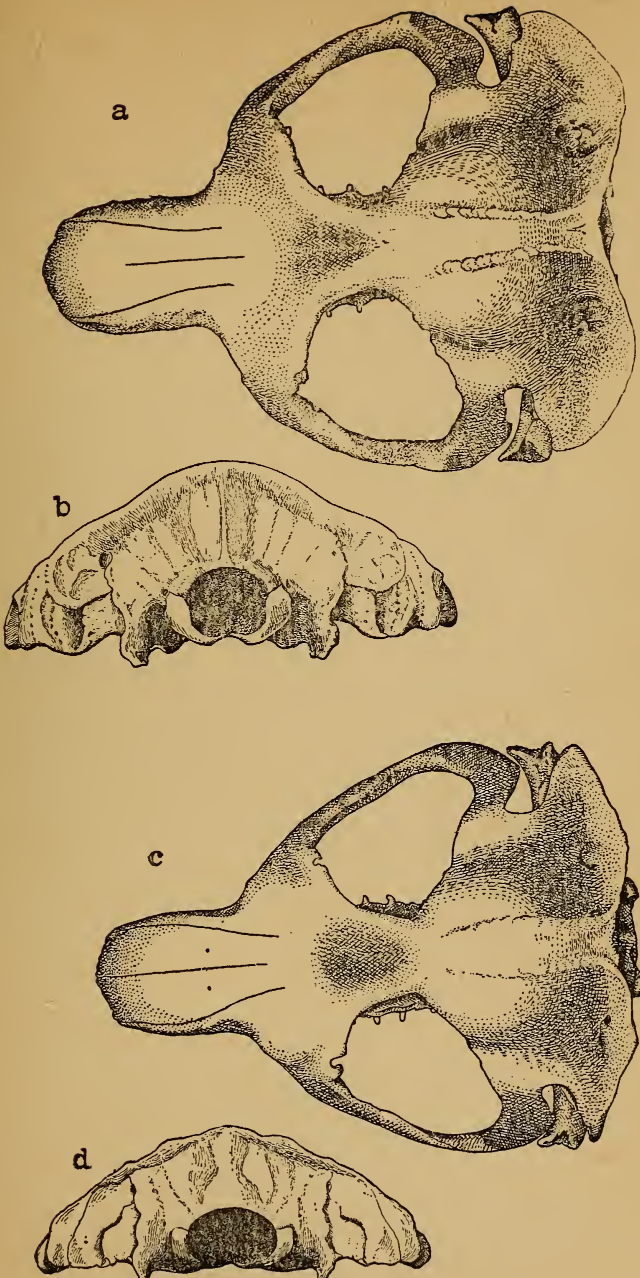


T. Sinclair & Son, Phila.

1. SPIRAXIS MAJOR. 2.3. SPIRAXIS RANDALLI.



Skull of APLODONTIA MAJOR ♂ ad. Nat. size.

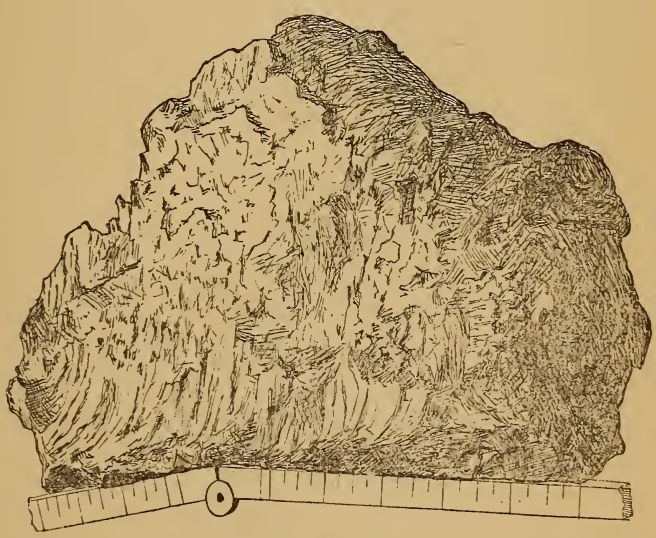


Comparative view of skulls of A. MAJOR and A. RUFA. Nat. size.
a, b, Aplodontia major ♂ ad. ***c, d,*** Aplodontia rufa ♂ ad.

Crust surface. Mass No. 2.
Two-fifths natural size, linear.

Mass No. 3.
Four-ninths natural size, linear.
Now in the collection of the Amer. Museum of Nat. History, New York.

Torn Side, Mass No. 1.



Torn Side, Mass No. 2.

Both one-third natural size, linear.

Disrupted Surface No 4.

Disrupted Surface No 5.

Disrupted Surface No 6.

All seven-tenths nat. size, linear.

Crust Surface No 4.

Crust Surface No 5.

Crust Surface No 6.

All seven-tenths nat. size, linear.

Fig. 4.

S

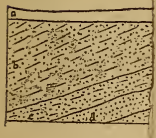


Fig. 5.

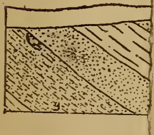


Fig. 1.

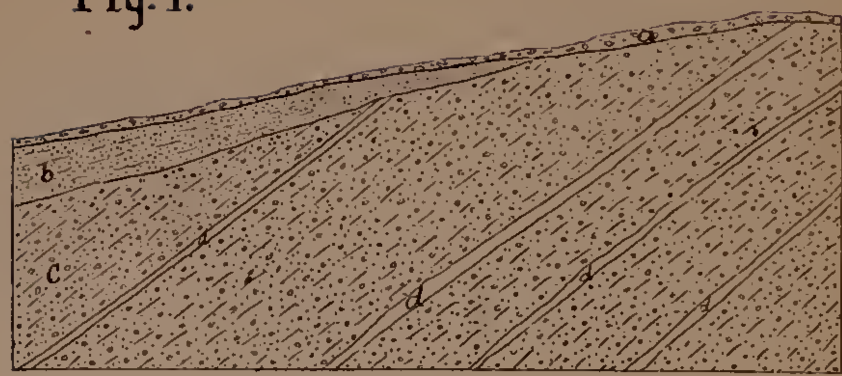


Fig. 2.

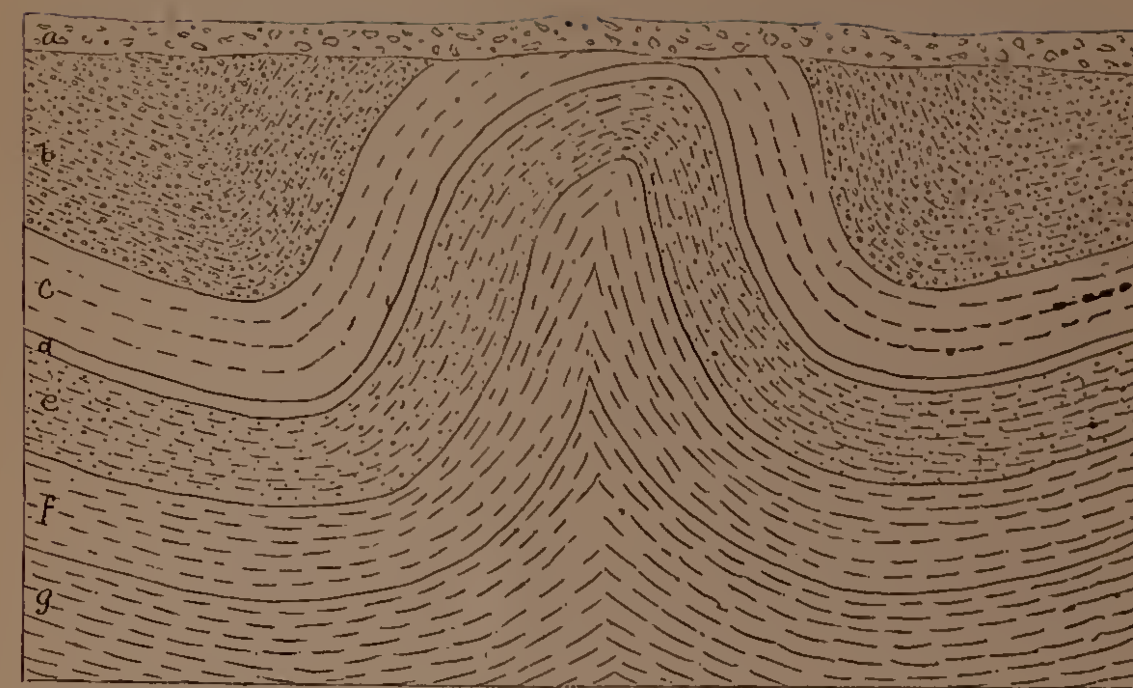


Fig. 3.

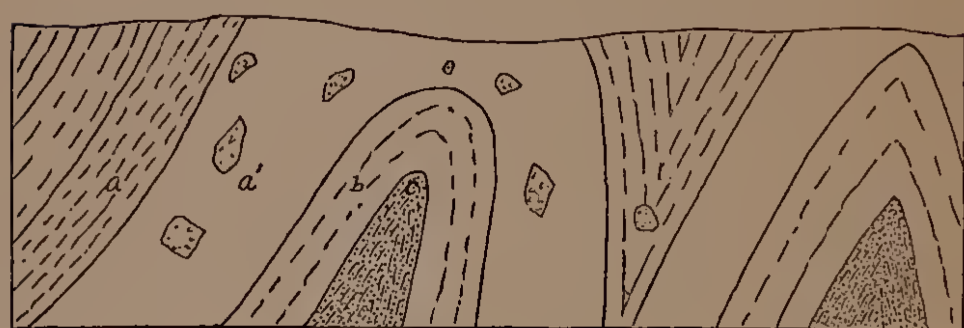


Fig. 4.

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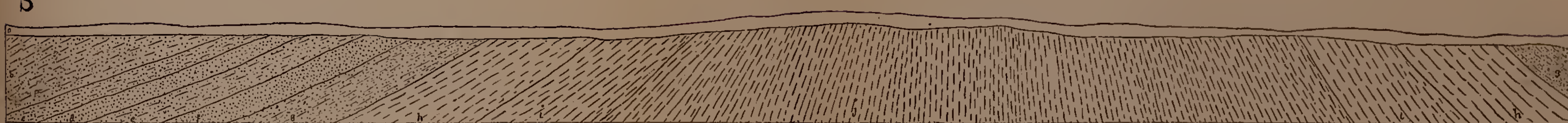

Fig. 5.

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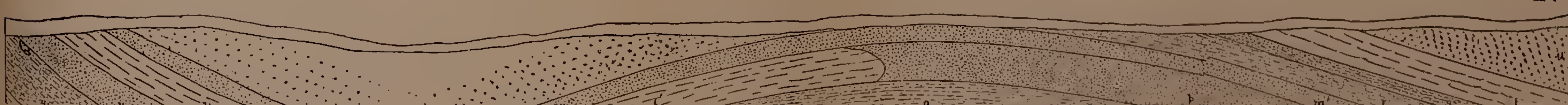

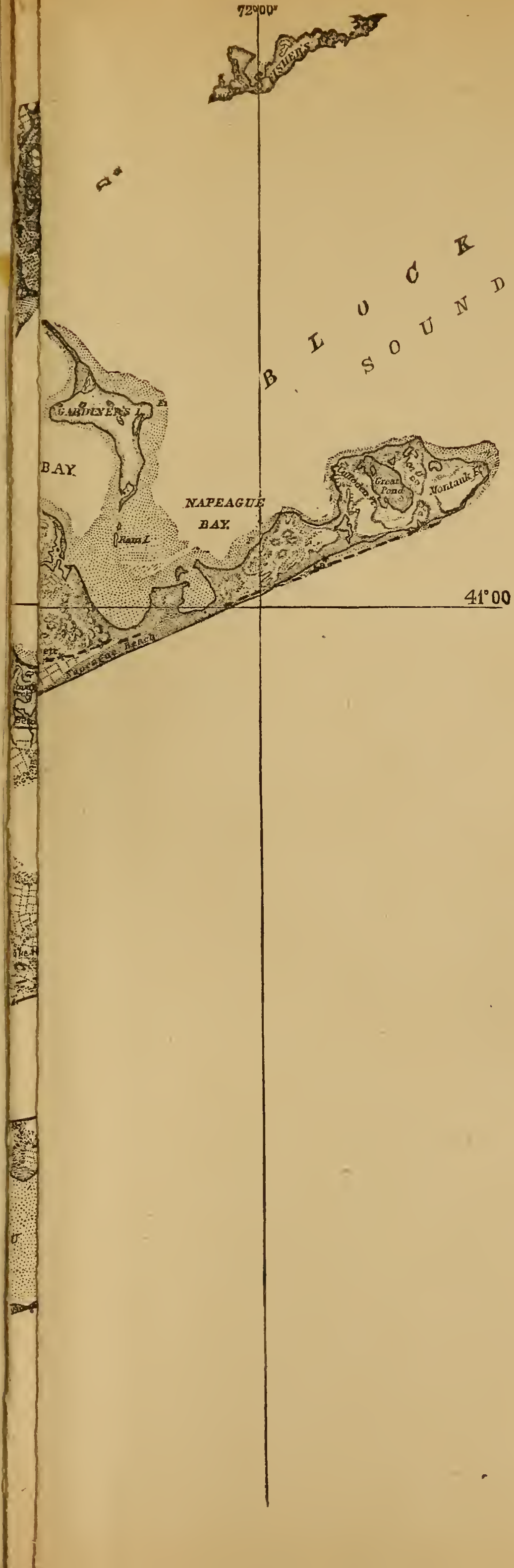

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B L O C K I.
S O U N D
GARDINER'S I.
BAY
NAPEAGUE
BAY
Ram I.
Great
Pond
Montauk Pt.
41°00
Napeague Beach


MAP
OF
LONG ISLAND,
SHOWING
THE SOUTHERN LIMIT OF THE ICE SHEET,
Adapted from the U. S. Coast Survey Chart
BY
F. J. H. MERRILL,
1884.
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NEW YORK
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LONG ISLAND
BLOCK I. SOUND
SMITHTOWN BAY
HEMPSTEAD BAY
GARDINERS BAY
NAPEAGUE BAY
PECONIC BAY
SHELTER ISLAND
GREAT SOUTH BAY
South Limit of Drift
73°00'
72°30'
72°00'
73°30'
41°00

ANNALS

OF THE

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VOLUME III, 1883–85.

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